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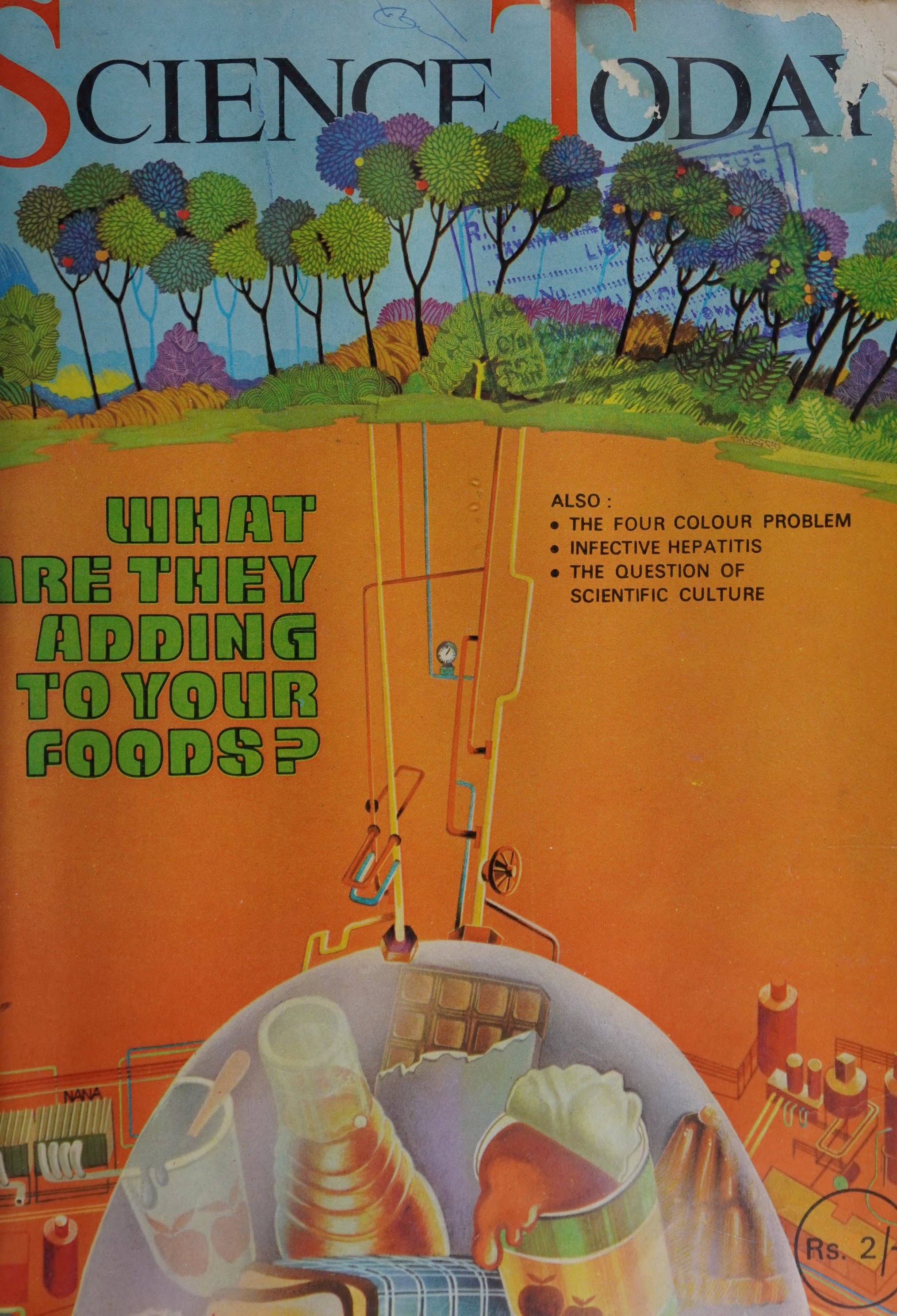

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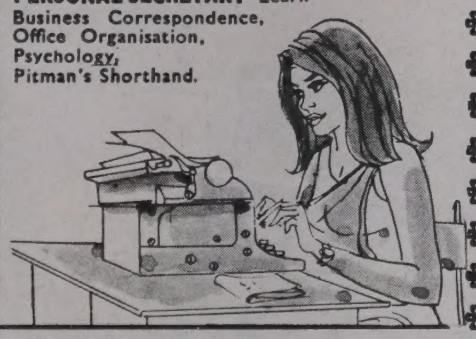

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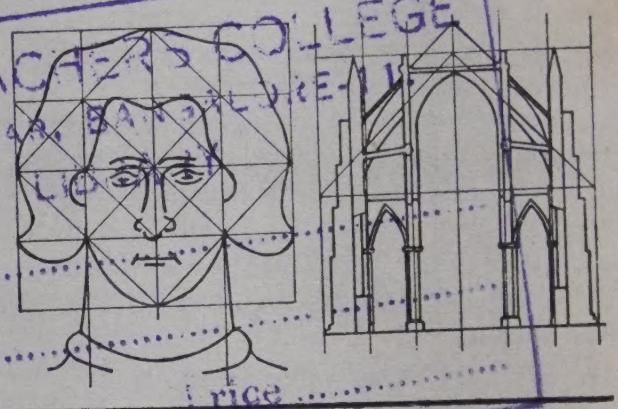

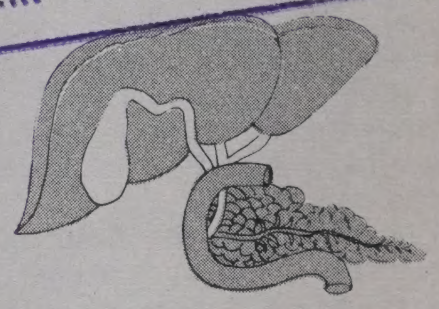

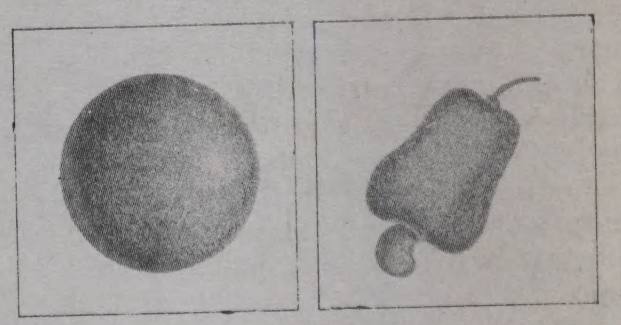

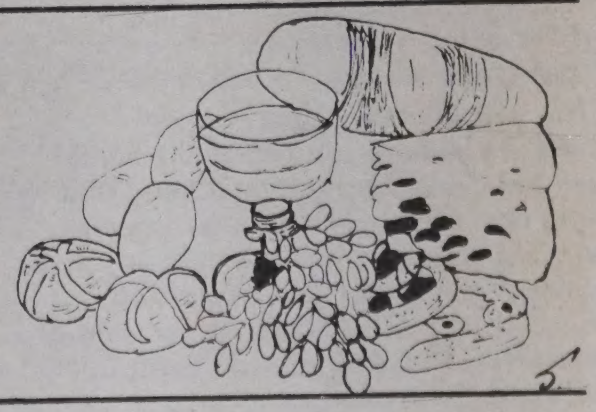

COVER

Painted by
Nana Shivalkar

EDITOR

SURENDR JHA

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LETTERS

Can fabric finishing processes harm the skin?

In " Cotton fabrics and finishing gimmicks " (April 1977), Dr. Shenai states that when cloth is subjected to treatments by chemicals such as sulphates of barium, calcium and ammonium, chlorides of magnesium and ammonium, formaldehyde and melamine formaldehyde, and DMDHEU, etc before finishing and marketing, the chemicals are left over on the cloth. Do these chemicals harm the skin of the person who wears it? If so, to what extent?

Dr. Shenai has also mentioned that optical whiteners used to give clothes a dazzling white effect absorb ultra-violet rays from sunlight and the absorption depends upon the concentration of optical whiteners. Do these ultra-violet rays adversely affect the health of the wearer of these garments?

D. V. V. SWAMY
20-77-2, Golla Veedhi
Chengalarao Peta
Visakhapatnam-530 001

Dr. Shenai writes : **The points are pertinent. Most of the chemicals used in textile finishing and applied to fabrics are washed off from the fabrics during their subsequent washing treatment; most of these chemicals are soluble in water. Compounds like ammonium chloride decompose into ammonia (which is given out) and hydrogen chloride, which is subsequently washed. Resin precondensates are also washed off from the fabrics. However, certain catalysts like zinc nitrate, magnesium chloride, etc may form insoluble zinc hydroxide and magnesium hydroxide, which may get deposited on the fabric, and are difficult to remove. It is likely that traces of these may remain in the fabric. About the toxicity of such chemicals, I have not come across any work carried out in this field.**

The second point about optical whiteners is more serious. While some work has been reported indicating that the optical brighteners themselves are not toxic, no study has been reported, to my knowledge, on the effect of the absorbed ultra-violet light on the skin of the wearer. However, cotton cloth treated with optical whiteners and exposed to sunlight has been conclusively shown to undergo more damage than cloth without the optical whitener. Therefore, at the moment, it is not possible to say definitely whether the optical whitener on clothes is harmful or not. Research needs to be done in this direction.

Relevant technology?

The contents of the advertisement " Relevant technology for the millions " by Hindustan Lever in SCIENCE TODAY (January 1977, p. 2) have come in for sharp criticism by the British journal *New Scientist* (10 March 1977, p. 591). *New Scientist* questions the HL claim that the beneficiaries in the *sal* seed business are the Adivasis. It says that most of the benefit goes not to the poorest, but the rich and powerful middlemen and a foreign controlled multinational, that is, Hindustan Lever.

It would be worthwhile to reproduce the following paragraph from *New Scientist* dealing with the so-called " benefits " to the Adivasis : " But what about the Adivasis? There are two keys to understanding how they have been affected by the *sal* boom. First, the *sal* season lasts a month or so. Second, contractors pay *sal* seed collectors only Rs. 3-4 per day. For each kilogram of oil, the contractor pays the Adivasi collectors only Re. 1 for the seeds, but receives Rs. 12 from HL. After processing the cocoa butter substitute, HL receives Rs. 20 per kg. The Adivasis see only 5 per cent of the value of their product ". The report goes on to say that by appropriate technology an equipment could be developed which could be used for processing the seeds by the Adivasis themselves by forming collectives. Since seeds can be stored, processing can extend over a large part of the year, thereby providing gainful employment to Adivasis, and increasing their income ten-fold.

V. VENKAPPA
Malaviya Regional Engineering College
Jaipur (Rajasthan)

Anti-amoebic combinations: are they therapeutically sound?

Currently, a large number of anti-amoebic drug combinations are flourishing in the market. Many of these contain at least three different groups of drugs : (i) an intestinal amoebicidal agent — iodochlorohydroxyquinoline or diiodohydroxyquinoline ; (ii) an extra-intestinal amoebicidal agent — chloroquine phosphate ; and (iii) an antibiotic — tetracycline or oxytetracycline. These do not act directly on the pathogenic amoebae but act by interfering with the enteric flora essential for the growth of the amoebae.

Practically, all these preparations are recommended for use as two tablets or capsules three times daily. An examination of the components of these combinations reveals that preparations Nos. 1 (Alliquine Fort tab), 2 (Amicline tab), 3 (Amebiotic cap), 4 (Iodocycline tab), 5 (Triquin cap), 6 (Amebide T.C. tab), 7 (Tequinopil tab) and 9 (Antecline tab) provide chloroquine phosphate as a maintenance daily dose (500 mg/day) which is less than the adequate quantity of 1 gm/day required for initiating the treatment, while preparation No. 8 (Esticline tab) has an adequate dose for starting the therapy but this is too high a dose for the maintenance therapy. The problem of providing the correct dose of chloroquine has been posed only because of the currently much employed " fixed dose " pattern of therapy which can cause both under- and overdosage problems, of which this is a glaring example.

In a large number of these preparations — Nos. 2, 4, 7 and 9 — the antibiotic is present in a sub-therapeutic dose ; the daily administration may be much less than the normal 1 gm required. It is, therefore, not only ineffective but positively harmful as it is likely to cause resistance in the micro-organisms. Moreover, in preparations Nos. 1, 2, 4, 5, 6, 7 and 8, the antibiotic included is tetracycline instead of oxytetracycline, despite the fact that the latter is superior. Preparation No. 7 has also a low dose of quiniodochlor (iodochlorohydroxyquinoline).

In our opinion, none of these combinations is suitable for both initial as well as maintenance therapy in amoebiasis. We are, however, seriously concerned with the composition of preparations Nos. 2, 4, 7 and 9, that is, Amicline tab, Iodocycline tab, Tequinopil and Antecline, which, for reasons given above, result in wasteful expenditure by sub-therapeutic doses of tetracyclines. We feel that this is a glaringly preposterous state of anti-amoebic combinations in our country and hope that the Drug Control Department will look into these serious inconsistencies.

P. C. DANDIYA
Professor and Head
Department of Pharmacology
S. M. S. Medical College
Jaipur-302 004
J. S. BAPNA
S. K. PATNI
University College of Medical Sciences
Ring Road, New Delhi-110 016

Remote pressure indicator

The remote pressure indicator (April 1977, p. 47) claimed to have been developed by Mr. H. C. Sharma is not new to those who are acquainted with Russian process control instruments. An identical principle has been extensively used long ago by the Russians in their Bϕ series instruments. Further, there is no question of commercialisation of Mr. Sharma's instrument since, based on the same principle, Instrumentation Ltd., Kota, has already produced, in collaboration with Russia, a series known as FM (ferrodynamic monitoring). Both Bϕ and FM series instruments have already been used on a large scale in the Bokaro and Bhilai steel plants.

N. GOPINATH
S. RAMMOHAN
MECON, Ranchi-834 002

Guns with magnetic ring

The new gun which requires the owner to wear a magnetic ring to fire it (May 1977, p. 9) may not always be fired only by the owner as far as criminals are concerned ; the magnetic ring may become a common item in the underworld. However, the magnetic ring may prevent several fatalities from guns going off accidentally.

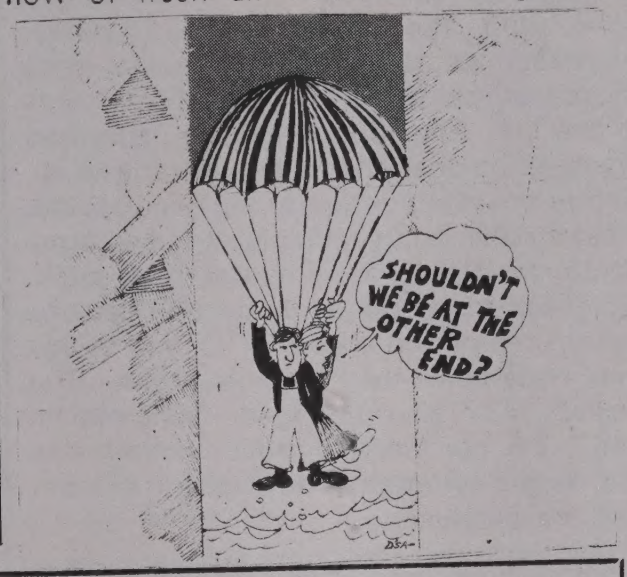
BHUMESH MATHUR
Junior Executive Trainee
Fertiliser Corporation of India Ltd,
Bombay-400 074

LIFE MOLECULES IN MARTIAN DUST CLOUDS

Hoping against hope seems to be the distinguishing trait of the would-be founders of Martian biology. Viking's biology experiments were a let-down, but, after all, the probes sampled only two points on the planet's surface. A much broader sample of Martian surface material could be present in dust clouds such as those witnessed in the 1971 storm by the Mariner 9 probe, say H. Abadi and N. C. Wickramasinghe of the University College, Cardiff (UK); in fact, the spectrum of these dust clouds shows a feature which Fred Hoyle and Wickramasinghe had earlier considered as the signature of highly complex organic molecules in interstellar dust (see SCIENCE TODAY, May 1977, p. 11). The "absorption band" in the spectrum, which has a wavelength close to 2,200 Angstroms (1 Angstrom = 10^{-10} metre) has been found in a wide class of organic molecules. More accurate and extensive spectroscopic studies of Martian dust clouds may throw light on the question of complex organic molecules and primitive life-forms on Mars, say the scientists in a report in *Nature* (23 June, 1977).

PARACHUTE FOR MINES

A unique parachute developed by the US Interior Department's Bureau of Mines unfurls to block the flow of dangerous gases in mine explosions or to direct the flow of fresh air wherever it might be needed. Anchored to the ceilings of walls and passage-ways, the prototype chute has a sturdy hemispherical centre to contain air flows and a squared-off skirt that flares out to fit into irregularities in the rocky walls or ceilings. Tests are being conducted.



ECSTASY THROUGH ENEMA

The hallucinogenic route to Paradise was known to the Mayas, the creators of one of the most flamboyant and intellectual civilisations of the New World, but they used an unusual short-cut — the enema — to reach there sooner.

The first evidence of this ritual was found in a Maya vase dating from the classic Maya phase (third century to seventh century AD). The vase depicts seven male-female pairs in horizontal rows: one of them is shown having enema administered to him by his consort; another is doing it himself. In between the couples are vases full of a foaming, fermented liquid, probably balche, a common alcoholic drink at the time of the Spanish Conquest. Writing in *Natural History*, March 1977, Peter T. Furst and Michael D. Coe conclude that the people in the vase are taking intoxicating enemas, a practice previously unrecorded for this culture.

Obviously, the Mayan Indians had discovered that the rectal administration of intoxicants could alter one's state of consciousness more rapidly and with fewer side-effects than taking them through the mouth. The principal function of the large intestine is to reabsorb liquids into the system and to store wastes until they can be evacuated. A liquid injected into the rectum immediately enters the bloodstream, which carries it to the brain. In the rapidity of its effect, a rectally injected intoxicant or hallucinogen closely resembles an intravenous injection.

The elucidation of the scene depicted on the vase has also made clear previously enigmatic scenes in Maya vases from central Veracruz. Hitherto, these were considered as representing human sacrifice, but the expression on the faces of the reclining males is of ecstatic trance, not death; the posture — legs raised or propped over a support, with the feet up in the air — also suggests the intoxicating enema.

Thus, while in the Old World the enema has been used — even in the ancient civilisations — primarily for clearing the bowels, the native Amerindians used them to introduce medicine and intoxicants into the body.

THE TWILIGHT OF THE ORANG-UTAN

The gentle 'man of the woods' — the orang-utan — seems to be on the way out. All over Malaysia and Indonesia, reckless logging is wreaking havoc with his forest home. Perhaps the lessons learnt from rehabilitating the orang-utan in rehabilitation centres could open a few eyes amongst those in India who are trying to find new homes for declining species like the Gir lions.

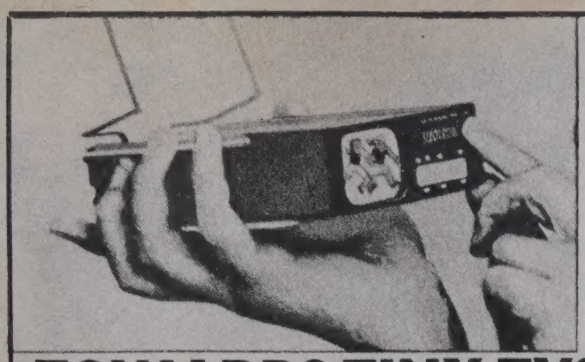
About a thousand orang-utans are made homeless every year by forest clearance. These, as well as animals confiscated from smugglers who meet the demands of pet-fanciers, are sent to rehabilitation centres at Sepilok and Bohorok, but the record of these stations has not been impressive. Many animals have died of sickness or predation. The objective ultimately is to return them to the wild population, but this has been rarely successful. Homeless orang-utans become bad tempered; and, since orang-utan biochemistry is similar to man's, they acquire human diseases from contact with humans; hence, releasing physically and psychologically sick animals into a healthy wild population has its own dangers. Worse still, some of the stations have been promoted as tourist centres, which probably makes it difficult for young orang-utans to revert to the wild life they hardly know.

ANOTHER CONFESSION OF FRAUD . . .

When a scientist's work cannot be repeated by other scientists, there is the suspicion of error, or even tall claims! The case of Dr. Summerlin and his painted mice in the USA is of recent memory.

The latest poseur is Dr. Robert Gullis who worked at Birmingham University (UK) and later at the Max Planck Institute for Biochemistry in Munich (Germany) on the effect of neurotransmitters, or chemical messengers (like noradrenaline), on cell membranes derived from guinea-pig brains. Eventually, Dr. Gullis got his PhD on the basis of this work. Now in a statement published in *Nature* (24 February 1977), he has confessed that the extensive data relating to his work and published in *Nature*, *The Biochemical Journal*, etc, were not experimentally determined.

What Dr. Gullis had apparently done in his PhD work was to show that a certain



TOWARDS TINY TVS

Bigness is not everything, not even in TV screens. In many of the portable TV sets being put out in Western countries, the small screens make the image look sharper and crisper, just as a wallet-sized photo often hides the blurs and imperfections of an enlargement. The picture quality in these small sets is excellent. One of the hottest new take-alongs is a set having a 5 cm diagonal screen and weighing 570 grams. Costing $300 (about Rs. 2,500), the set manufactured by a British concern, is smaller than the average paper-back book.

reaction in the cell membrane was affected by 'messenger' substances on both sides of the cell wall, thus affecting the membrane's properties. The crucial stage was the measurement, by means of a 'scintillation counter', of the uptake of a fatty acid labelled with a radioactive isotope, and it is here that the fraud was alleged to have taken place at Munich. It was detected when other workers, including those at the Munich Institute, were unable to reproduce his results. Dr. Gullis admitted that his data were not based on bonafide experiments, and wrote to *Nature* confessing that eight papers of his were based on "hypothesis".

Apart from the time that Gullis himself has wasted, it is estimated that at Birmingham alone, researchers have wasted four man-years vainly trying out Gullis's methods.

Gullis's motive? The same as Dr. Summerlin's — the craze to produce results. "They were just after results," he says of the University authorities. What made it easier to fudge the results was that they were *expected*!

One unsolved problem for *The Biochemical Journal* is what to do with papers awaiting publication which cite Gullis's work.

VACCINES MIGHT SPREAD DISEASE GERMS

Eternal vigilance is the price of freedom from disease. The fact that no cases of a human disease have been reported does not mean that it has died out. It may be lurking in an animal population or may be in the process of mutating into a new strain (like the influenza viruses). Another possibility is that where an attenuated live virus is used for inoculation as in the Sabin polio vaccine, strains similar to the vaccine strain may gain a foothold in the population. More so, because the remarkable success of the polio vaccine has encouraged the use of attenuated live viruses against other common virus infections.

In England and Wales, though polio cases have become fewer since the live (Sabin) vaccine was introduced in 1962, many strains are still being isolated from apparently healthy persons who have neither been vaccinated nor have had contact with a recently vaccinated person. Dr. Yvonne E. Cossart, a bacteriologist now with the University of Sydney, Australia, compared such strains with those from suspected poliomyelitis victims in the UK. She found that the virus had changed its character over a decade or so. Before the introduction of the live vaccine, most strains could multiply at raised temperatures. Now, many strains from polio victims or from apparently healthy persons cannot reproduce above 37°C, and in this they resemble the vaccine strain. The disease has also changed: whereas in 1957, 66 per cent of polio victims had the classic symptoms, now less than one-half are paralysed.

However, since the wild strains and the vaccine-like strains differ only slightly, it is important that immunity to the former is maintained by vaccination, Dr. Cossart cautions in a paper in the *British Medical Journal* (25 June, 1977).

AN ABM BEAM

American military circles seem to be agog with rumours, set off by an *Aviation Week* article last May, that the Soviets have developed a particle beam weapon as their anti-ballistic missile defence. The supposed evidence for the report consists of reconnaissance satellite pictures of certain installations at Semipalatinsk and at Azgir (near the Caspian Sea): at the latter site there is a large main building with an underground granite cavern nearby in which there are two thick hollow spheres; pipes lead from the chamber. According to the journal, the granite chamber is a fission explosion generator, using a train of nuclear explosions to drive metal through a magnetic field. From the generator, power is carried through cables to giant capacitors in the surface building. Power from the capacitors is fed into a 'collective accelerator' and an electron injector gun to produce a beam of protons.

One advantage with a particle beam weapon would be that, travelling at the speed of light, it could reach its target much sooner than a conventional missile interceptor, but aiming it could be a problem, because deflections in the Earth's magnetic field could tug the beam about.

Sceptics say that the 10 megajoule energy level that the device would require to destroy a target could as well be obtained from a conventional high explosive. Writing in *Science* (27 May 1977)

DO AGEING STARS STOKE THEIR FIRES?

Looking at the extreme ultraviolet (EUV) part of a star's spectrum has been an eye-opener for astronomers, and may well revise our ideas about what happens to a star in its old age. (The extreme ultraviolet lies in between the far UV and the soft X-ray region of the spectrum; most astronomers had believed that it was useless to expect to see stars in the EUV because the junk in interstellar space—mostly hydrogen—would absorb all the radiation.)

But Stuart Bowyer and his associates at the University of California (USA) thought otherwise. They felt that interstellar matter is not of uniform density; in between the denser patches, the density is only one-tenth the average density.

Bowyer's group flew a EUV telescope on the Apollo-Soyuz joint mission (1974). (The telescope has no imaging capability but determines if a given source is radiating EUV.) One surprise of the experiment was the finding that the hot white dwarf HZ43 in Coma Berenice (a white dwarf is a star that having exhausted part of its nuclear fuel occupies a much smaller volume and has a high surface temperature) has a high temperature of about 110,000°K—which is 17 times the surface temperature of the Sun and is high even for a white dwarf. The dark companion (Sirius B) of the Dog-star, Sirius, turned out to be 10,000 times as

Sirius A outshines Sirius B (at top)

bright in the EUV as it is by visible light and its temperature is read as 30,000° to 35,000°K. (Sirius B by optical light is a small faint dwarf dominated by its giant companion.)

According to Bowyer, such results, especially for HZ43, might necessitate changes "in the theory of the end point of the evolution of a star".

Nicholas Wade opines that, at the most, the Soviets may possibly be experimenting with a particle beam weapon.

SUICIDES AND MOTOR ACCIDENTS

In the USA, publicity given to suicide stories in newspapers was found to have a direct relation to motor vehicle fatalities. A paper published in *Science* (24 June 1977) by sociologist David P. Phillips of the University of California at San Diego, USA, says that the rise apparently occurs because some persons tend to imitate the publicised act. Earlier, in 1974, Phillips had shown that suicide levels rose after publicised suicide stories.

For his present work, Phillips examined the front-page suicide stories that had appeared in the Los Angeles *Times* and the San Francisco *Chronicle* and noted the corresponding weekly road fatalities. The correlation was quite extraordinary. For instance, road fatalities in California increased by an average 18·33 per cent during the week following the suicide of Japanese author Y. Mishima in 1970.

GENE-"SWITCH" SYNTHESISED

The on-off switch of a bacterial gene has been chemically synthesised, slipped into bacteria and observed to subvert normal gene control.

Researchers at Cornell University, USA, constructed a DNA segment that controls the group of genes involved in *Escherichia coli's* use of the sugar, lactose. The synthetic segments were linked into DNA plasmids and, thus, carried into bacterial cells.

Several laboratories are now attempting to attach such control segments to maintain genes to coax bacteria into making desired proteins such as insulin.

A SLOW VIRUS COULD CAUSE SENILITY

The belief that a virus could be behind human senility has come from an understanding of scrapie, a neurological disorder of sheep, kuru, a disease reported first among New Guinea cannibals, and Creutzfeldt-Jacob disease (see SCIENCE TODAY, December 1976, p. 51). These are all similar in that months or even years may pass before disease symptoms show up.

Now John Hotchkin and Ruth Buckby of the New York Department of Health, Albany (USA), have neatly demonstrated that in scrapie the infection is acquired at birth and has a long incubation period. The causal agent is unusual, not only in being extremely small but also in possibly lacking the nucleic acid common to all known life-forms.

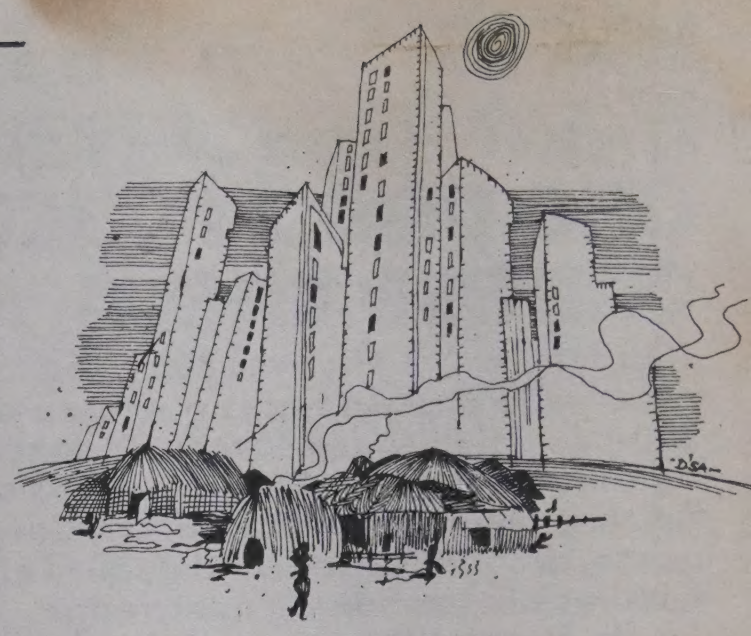
The scrapie virus being transmissible to mice, the scientists inoculated newborn mice with it. The animals showed no signs of the disease for one year, but by 18 months began dying faster than a group of uninoculated animals (the 'controls'). The scientists suggest that the virus remains latent for about one year, then becomes active, multiplying in the thymocyte cells of the immune system and finally producing the disease symptoms.

Writing in *Science* (6 May 1977), the scientists say that their work has an important bearing on diseases similar to Creutzfeldt-Jacob disease and kuru disease; if infection occurs at birth, and there is a long incubation period, it would naturally make them difficult to distinguish from genetic diseases.

TOMORROW'S WORLD—A SLUM?

Dr. Samuel Chamecki, consulting engineer and head of UNESCO's research section in engineering sciences, says that already slums and slum-like settlements account for 33 to 50 per cent of the population of cities in developing countries. "One-third of the world's population is either currently homeless or housed in substandard lodgings", he says.

And it is quite possible that architects and urban planners will be unable to do anything about it. Madhu Sarin, an Indian architect now at the University College, London, cites the case of Chandigarh, the well-planned (by La Corbusier) capital of Punjab. Chandigarh has a population of 250,000, 15 per cent of whom live in squattered settlements. "High rents and overcrowding have become the norms in low-income residential areas. While the rich (with ample economic choice) command space, the poor are trapped in it", she says.



The sweepers, gardeners, rickshaw-pullers and hawkers that Chandigarh needs are provided by these ever-expanding slums. Sarin wonders how much progress these slums can make as long as the inhabitants remain at the bottom of an economic power structure.

The problem is not Chandigarh's alone. Will the cities of the future be large aggregates of ugly slums?

UNDERWEIGHT WOMEN AND THE PILL

Underweight women who have unpleasant initial experiences while taking to oral contraceptives would do well to remember that body weight is one of the factors which determine the action of a drug.

It has been noticed that women vary in their reactions to oral contraceptives, which are based on hormones; yet it would be complicated to take into account their internal hormonal make-up before prescribing the pill. One factor which can be studied easily is body weight, and last year it was reported that underweight women are more likely to miss their periods when they go off the pill.

Following this cue, Dr. Prem P. Talwar of the International Fertility Research Programme, North Carolina (USA), and Dr. Gary S. Berger of the University of North Carolina gave oral contraceptives, in three cycles, to 480 healthy women of reproductive age. Their physical traits like height, weight and blood pressure were recorded when the trial began. Every two weeks, a nurse phoned up the women to enquire about possible side-effects.

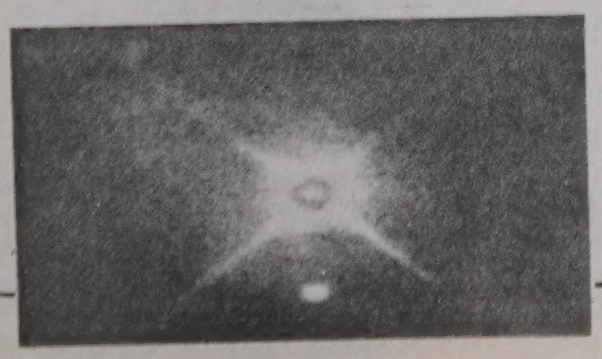
It was found that overweight women had the fewest side-effects like cramps, vomiting and depressions, as compared to underweight women. In the case of vomiting, the difference was most marked. Only in the case of headache did the overweight women suffer more. However, the authors note in their paper in the *British Medical Journal* (26 June 1977) that the differences tended to disappear in the third cycle and hence all women who experience side-effects with oral contraceptives should remember that these are likely to decrease by the third cycle of use.

THOSE "SHOCKING" DOG COLLARS

Some American dogs now wear a sound-activated collar which gives the animals an electric shock whenever they bark aloud. The collar which sells under such brand names as Wuf-E-Nuf and No-Bark Collar (at $40 each) has now come under fire after it was found that the collars sometimes produced a voltage 10 times that stated on their labels. Such high voltages, can burn a dog's neck. Worse still, any noise in the vicinity — car hooters, clapping hands, or another barking dog — can trigger off the collar unnecessarily.

SUPER-STAR

This remarkable photograph of the red giant star Betelgeuse indicates that it may be actually 400 times larger than our entire solar system. The picture was taken with new infrared enhancement equipment connected to the huge telescope at the University of Texas McConald Observatory (USA). The bright centre image is the star; the dot at the bottom is a ghost image. Betelgeuse, one of the best known stars in the winter sky, is in the constellation Orion.



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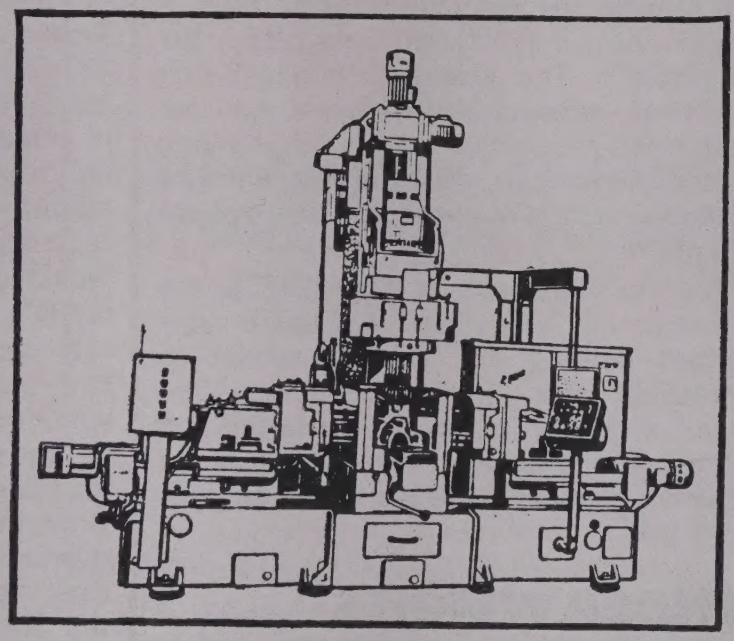

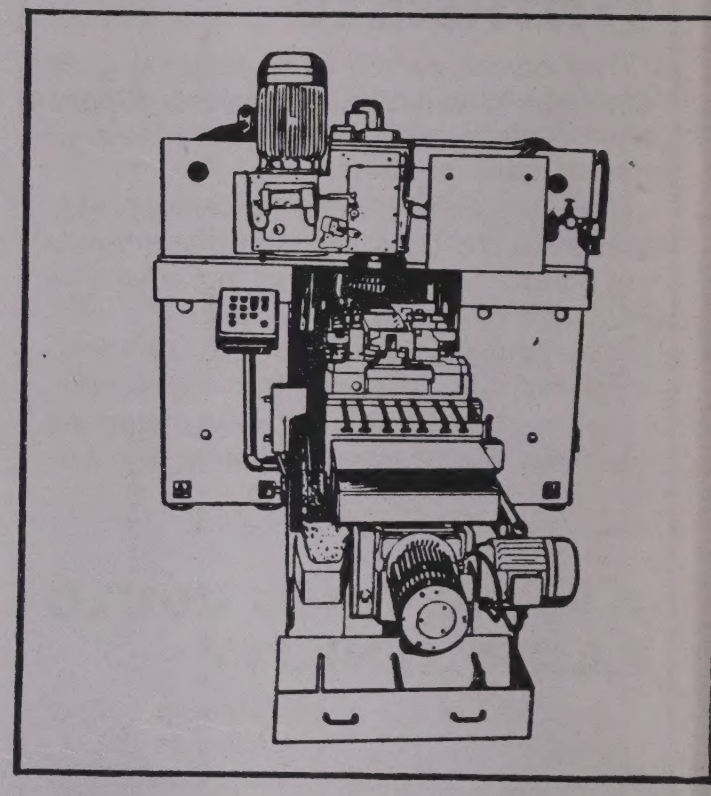

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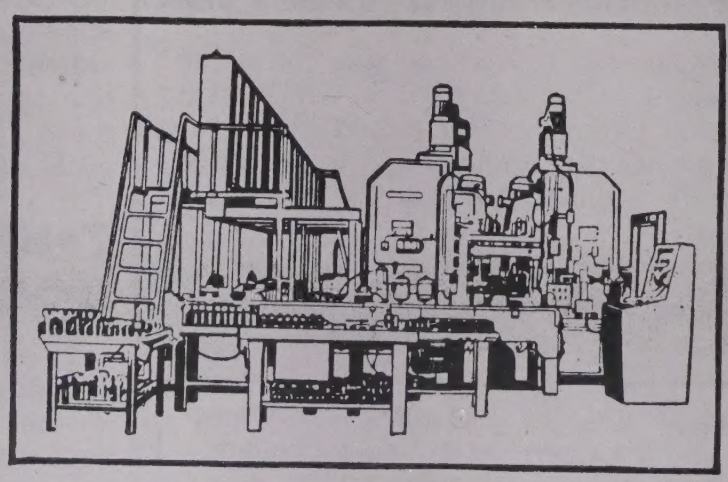

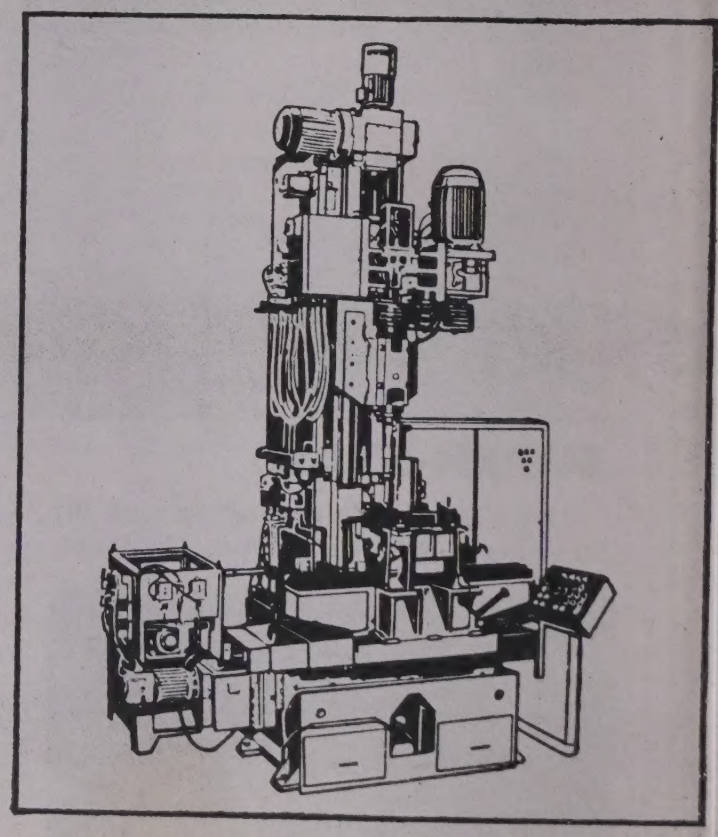

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Does cattle-breeding help the rural poor?

Which way are our rural development programmes heading? "It has been our common experience," write two active workers from Kishore Bharati, a well-known voluntary rural development agency in Madhya Pradesh, "that when a technology demands a high level of capital investment and a wide contact with bureaucracy, industry and urban centres as preconditions for its adoption in rural areas, the benefits are usually siphoned off amongst the already economically and socially powerful rural elite." They express serious concern over the indiscriminate transfer of technologies to rural areas.

Their observations, based on their own experience as well as that of a few others, assume added significance in the context of the Janata Party's clearly stated commitment to an overall development of the agricultural sector, specially to the upliftment of the rural poor. The Janata Party programme has stressed the importance of animal husbandry, aqua-culture, agro- and rural-based industries, etc as tools for rural development. Particularly, "dairying has a great future based on the wealth of Indian cattle which can be upgraded", says the Party's election manifesto. But, how far have these measures really helped the rural poor?

Some of the issues raised by the two workers, Anil Sadgopal and Rex D'Rozario, need to be widely discussed. Dr. Sadgopal, one of the initiators of the over six years old Kishore Bharati, was until 1970 *a researcher with the Molecular Biology Group at the Tata Institute of Fundamental Research, Bombay. Mr. Rozario, a former colleague on the editorial staff of* SCIENCE TODAY, *joined the project three years ago. Below, we reproduce extracts from their letter:*

It is often argued in defence of transfers of such technologies to rural areas that a 'percolation effect' occurs which benefits the weaker sections; the fresh inflow of investment helps in building up an agro-based industrial infrastructure, and this, in turn, increases the employment potential of the landless labour, the marginal farmer and the village artisan groups. However, the rate of increase in incomes of the rich and the poor as a result of introduction of such techniques is so disparate that the gap between the two is further widened. And the poor become increasingly dependent on the rich.

Our attempts at taking technology directly to underprivileged groups have encountered tremendous obstacles. The rural elite, intent on retaining their stranglehold on a semifeudal economy, fight tooth and nail against any drastic changes in the economic and social hierarchy. The bureaucracy and village-level extension services remain indifferent. Lack of finance inhibits investment and limits access to more remunerative markets. Industry often remains sceptical about the ability of such groups to successfully adopt a technology which demands proper management.

Let us examine this process, though briefly and rather superficially, with reference to the technology of cattle-breeding. We have surveyed and analysed various cattle-breeding programmes sponsored by the Government and voluntary agencies, including our own. The collective experience of using cattle-breeding as a tool in rural development has shown that the cattle-breeding technology is elitist. For example, take capital investment. Present trends in institutional financing put the cross-bred cow beyond the reach of the small and marginal farmer, the landless agricultural labourer, the village artisan, the petty shop-keeper and the Adivasis dependent on forest produce for a living. And these categories constitute over 70 per cent of the rural population.

The sophisticated nature of the technology is further illustrated by the technological tie-ups it demands. First, artificial insemination with frozen semen requires foreign collaboration for the supply of progeny-tested semen and insemination aids, liquid nitrogen manufacturing plants, and liquid nitrogen containers for storing the semen. Second, a cross-bred cow demands intensive veterinary care, and this brings the pharmaceutical industry into the picture for the supply of expensive veterinary formulations and vaccines. And then, when the market for milk is saturated, there is pressure to convert milk into products like butter, milk powder, cheese, etc. The capital-intensive conversion technology comes from the large industries, followed, in its wake, by high-salaried dairy technologists and managers. Rural areas thus come to increasingly depend on sophisticated technology, industrial expertise and high finance. Soon this siphons off a significant portion of profits, for the maintenance of high-salaried dairy technologists and managers. Large marketing networks and intensive advertising campaigns to sustain and widen the market cut further into the profits. The owner earns progressively less.

Given the more remunerative prices and greater demand for milk and milk products in urban areas, the phenomenon of rural areas depending upon, and producing for, urban markets soon becomes an unavoidable reality. And in trying to reach these markets, fresh relationships have to be created with the bureaucracy — transport, licensing and taxation officials, and veterinarians.

Policy-makers ignore another important aspect of cattle-breeding. The large green fodder requirement of a cross-bred cow makes it necessary to convert much-valued land under cereal production to the cultivation of fodder and ingredients of feed concentrates. Expensive irrigation facilities and scarce fertilisers, too, are diverted. In the process, there is a loss by a factor of about five in the total energy output per acre of land in terms of available food. That milk contains much-needed proteins for bridging the protein gap in India is not valid. What we lack is sufficient calories, not protein. Milk has no special advantages over a combination of cereals and pulses with regard to calories and essential amino acids.

The large farmer and trader will, of course, strongly lobby for the adoption of this technology. It is more remunerative and, therefore, in their interest. With the greater buying power they acquire, they soon increase the demand for unnecessary consumer goods and perpetuate a pattern of industrial growth that is irrelevant and damaging to the weaker sections.

The national policy of cattle breeding has thus favoured the elite. How can this policy be modified to help the poor?

Are there any alternative cattle-breeding technologies which can lead to economic and social equality in rural areas? Can cross-breeding be made less dependent on high finance and industrial and urban collaboration? How can one alter the existing cattle-breeding techniques so that cattle development will be relatively free of the critical influence of multinationals and international aid agencies? Can one design and carry out experiments to test various possibilities like: (*i*) converting marginal land into rain-fed pastures; (*ii*) using liquid semen stored in coconut water or other cheap media in place of more expensive frozen semen; (*iii*) evolving low-cost refrigeration techniques for semen and milk storage; (*iv*) improving and rationalising local veterinary medicines; and (*v*) reorganising the infrastructure for the supply of concentrates, vaccines and modern drugs so that they reach the poor without the interference of intermediaries like traders and the bureaucracy?

Why, in fact, is there a disproportionate interest in cross-bred cows? Why not buffaloes or goats? No doubt, the cow is a more efficient machine and can be improved genetically through cross-breeding, both in terms of regularity of breeding and milk production. But buffaloes are more hardy, easier to maintain, and their milk, with its higher fat content, is more acceptable in the market. Goats are cheaper in terms of capital investment and maintenance (see SCIENCE TODAY, July 1977, p. 26). More important, they can live off poor quality grass and scrubland; they do not raise the problem of converting cereal lands to fodder. Their maintenance increases the employment potential of the young in villages who graze them. These and many more questions need answers and, more important, concrete alternative courses of action.

S.J.

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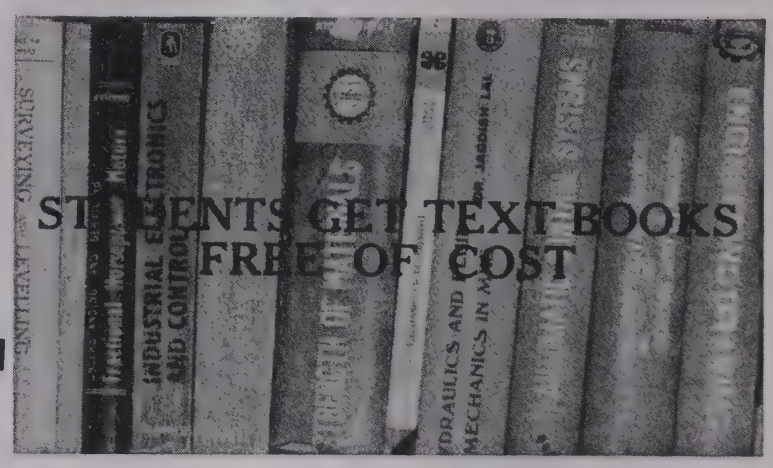

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(Left) Bowstring-operated boring machine for preparing pearl necklaces. The year is 1390. Five years later (right), the artisan is using a *foot-operated* lathe, with bowstring and spring. (Illustrations from the Mendelschen Zwolf-Bruder-Stiftung)

ACADEMIC SCIENCE AND TECHNOLOGICAL CULTURE

SOME LESSONS FROM HISTORY

R. NARASIMHAN

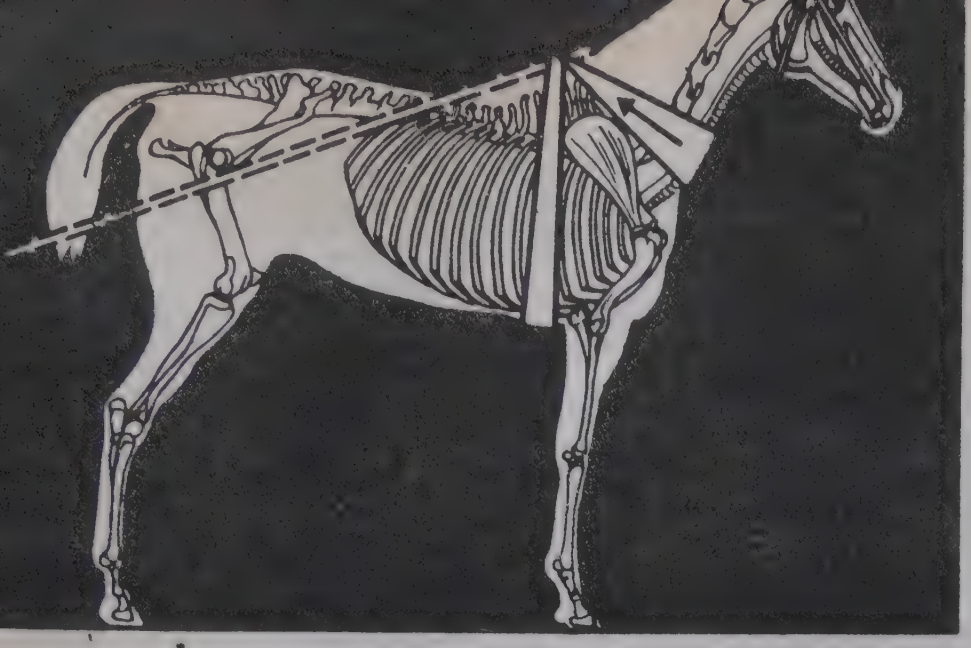
1. Does excellence in science lead to a technological culture?

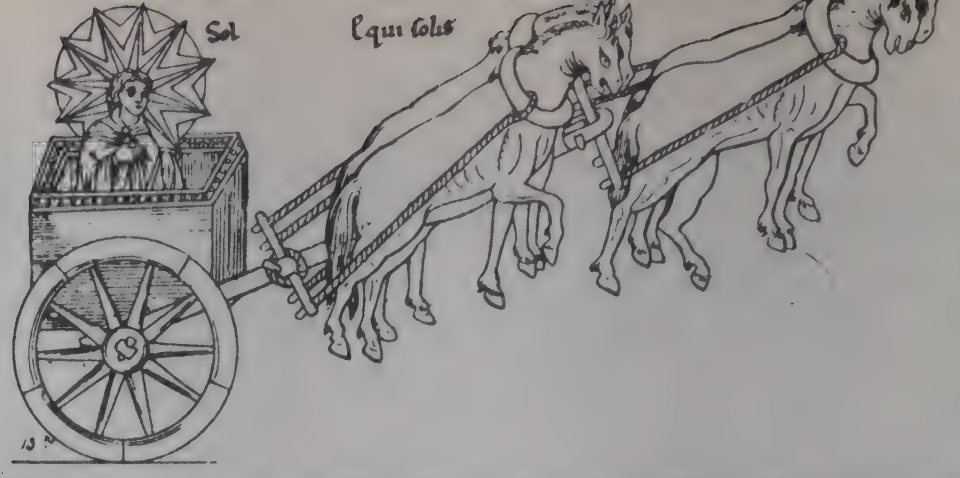
"It is well to observe the force and virtue and consequences of discoveries. These are to be seen nowhere more copiously than in those three which were unknown to the ancients, and of which the origin, though recent, is obscure and inglorious: namely, printing, gunpowder and the magnet. For these three have changed the whole face and state of things throughout the world, the first in literature, the second in warfare, the third in navigation, whence have followed innumerable changes: in so much, no empire, no sect, no star, seems to have exerted greater power and influence in human affairs than these mechanical discoveries."

So wrote Francis Bacon in a much-quoted passage in his *Novum Organum* published in 1620. The origin of these three 'inglorious' discoveries is no longer so obscure, for, now, historians of technology generally agree that all these three came to Europe from the Far East, most likely from China. (It is significant that none of these three discoveries were known in India till relatively recently.) Printing was known in China already in the 10th century. All the Confucian classics were in print by AD 930. Interchangeable type was invented in the Far East in AD 1045 and metal types were in use in Korea by AD 1390. The earliest extant printed material based on moveable type in Europe, however, dates only from AD 1454. Similarly, gunpowder was in use in China in the 8th–9th centuries. Magnetic compass seems to have been in use in China almost a hundred years before it came to be known in Europe. Apart from these discoveries, the medieval side-harness for the horse that is claimed to have increased its pulling power by a factor of four or five was already known in China by the early Christian era. The modern saddle, stirrup and bridle, and the nailed horse-shoe, which were introduced into Europe in the 9th or 10th century, and which were instrumental in effecting far-reaching changes in the art of warfare, were in use in Mongolia even earlier. Although watermills were already in use in Roman times, the harnessing of windpower was unknown in Europe till much before the 12th century. But windmills were being used by the Arabs in the 7th century and their use very likely was known at still earlier times in some of the high plateaus of Iran. It is now believed that the Europeans acquired the windmill technology from the Arabs. The Arabs, very likely, were also instrumental in introducing paper into Europe. (The art of paper-making was known to the Chinese in the 2nd century AD.) There seems to be some reason to believe that even the gear-driven clocks invented in Europe in the 14th century were inspired by the complex, gear-driven, 'computing devices', like the astrolabe and the equatorium, which the Arab astronomers were using in the 11th and 12th centuries.

Apart from these technological innovations which Europe acquired from the Middle East and the Far East in early medieval times and later, much of the 'science' (Euclidean geometry, Aristotle's natural philosophy) and 'engineering' (Archimedes, Vitruvius, Hero) of classical Greece and Rome was rediscovered around this time only through translations from Arab sources. Nevertheless, from these 'borrowed' beginnings in 'science' and 'technology', medieval Europe was able to forge, first a scientific revolution in about three to four hundred years, and subsequently, in less than another two hundred years, an industrial revolution.

Now, it is well-known that there was a strong base in the 'sciences' (in mathematics, astronomy and medicine) in India and China in medieval times. And, as we saw earlier, at least in China (and, possibly, to some extent in India also, although very little of the details of this is as yet known) there was an equally flourishing technological base. Yet, paradoxically, this highly





(Left) Ancient harness with neck and body girths. The illustration from *Histoire de la Locomotion Terrestre* shows how the neck girth pressed on the animal's windpipe. (Above) New medieval harness in drawing from Herrad von Landsberg, *Hortus Deliciarum*, early 13th century

developed, indigenous, intellectual and technological base in these countries of that time did not result in a scientific or industrial revolution comparable to the European one.

This strange state of affairs requires some explanation. What were the preconditions that existed in Western Europe that were missing in China and India, that in the one case technology and science could interact successfully, build on each other's strengths, and both move forward with explosive energy, while in the other case the condition of both science and technology at best remained stagnant and much of the time actually deteriorated?

Any plausible answer to this puzzle should be of more than academic interest. In fact, we can reformulate this puzzle in modern terminology by asking, " what is the relationship between ' academic science ' and technological culture? "

In countries like India (and the so-called third world countries), there is an obsessive pressure to transform the local societies to approximate the technological culture of the industrialised European and North American countries. Since the role of science in achieving this transformation is seen to be central and critical, it is taken to be axiomatically true that scientific excellence will automatically bring about a technological transformation. However, the historical evidence we have just been outlining would seem to directly contradict these beliefs.

The lesson we must draw from this contradiction is that we cannot expect to learn much about the true relationship between scientific and technological culture by studying the intimate relationship between science and technology that we see in the *current activities* of the technologically highly advanced countries. We must study the historical processes — the social and institutional forces — that were instrumental in bringing about the transformation in the technological culture of these societies that we see there today. In doing so, it is not the study of the history of science, per se, that is relevant, but the study of the history of technology and of the interaction between science and technology in the advancement of the latter.

Studies in the history of technology are of relatively recent origin and, unfortunately, the results of most of these studies are not readily accessible to the non-specialists. Thus, although many students of science have some knowledge of the history of science, most of them tend to know little of the history of technology. However, in the last decade or two several highly readable books and monographs on the history of technology in general, or one or more aspects of it in particular, have appeared. One of the more recent ones, and possibly also one of the best, is a book by Arnold Pacey, *The Maze of Ingenuity*. Also Musson and Robinson have published a collection of essays, *Science and Technology in the Industrial Revolution. A History of Western Technology* by Klemm contains excerpts from a variety of contemporary documents.

Even a cursory reading of these and similar works would make it abundantly clear that the development of a technological culture depends on a complex and intimate interaction *at the working level* between ' academics ' and ' mechanical artisans ' (interpreting both these terms in their widest senses). It is very rarely that these two roles are successfully combined in the same individual or in a group of individuals. Historically, one can identify a few such instances, especially in the formative stages of ' science ' and ' technology '. But most of the time, the interaction at the working level between concepts and ideas on the one hand, and implementations deriving from these on the other, have been predicated in an essential way on the availability of certain well-identifiable catalysing factors. I believe two of the most important of these have been: (1) a high regard for ' manual labour ' (broadly interpreted) in the community at large, the so-called ' work-ethic '; and (2) middlemen with a primary commitment to act as a bridge between the producers of ideas (concepts, theories, hypotheses, insights) and the producers of things (craftsmen, artisans, mechanics, and later on, industrialists and entrepreneurs). This bridge-building activity, historically, has found institutional manifestation in various forms: popularisation of ideas through publications of books, journals, encyclopædias, through lecture-demonstrations, through the organisation of schools outside the established educational system (' dissenters' academies '), and, finally, through ' philosophical clubs '.

In the rest of this article I would like to substantiate my thesis by considering the role of these two factors at two distinct periods in the development of Western technological culture: (1) at the time of the rapid technological transformation of Western Europe during the 12th and 13th centuries; and (2) at the time of the Industrial Revolution in England and America in the late 18th and 19th centuries.

2. ' Work-ethic ' and the mechanical arts

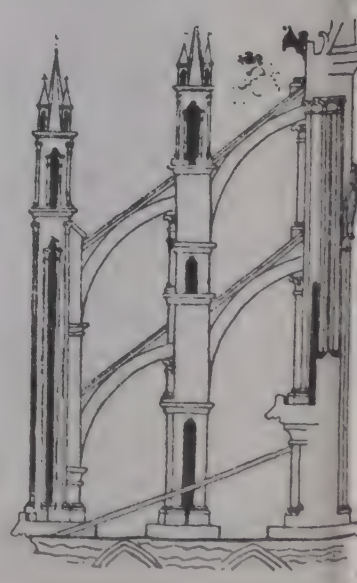
The controversial views of Weber, Tawney, and other sociologists and historians claiming a decisive role for the ' work-ethic ' of

GEOMETRY AND THE GOTHIC

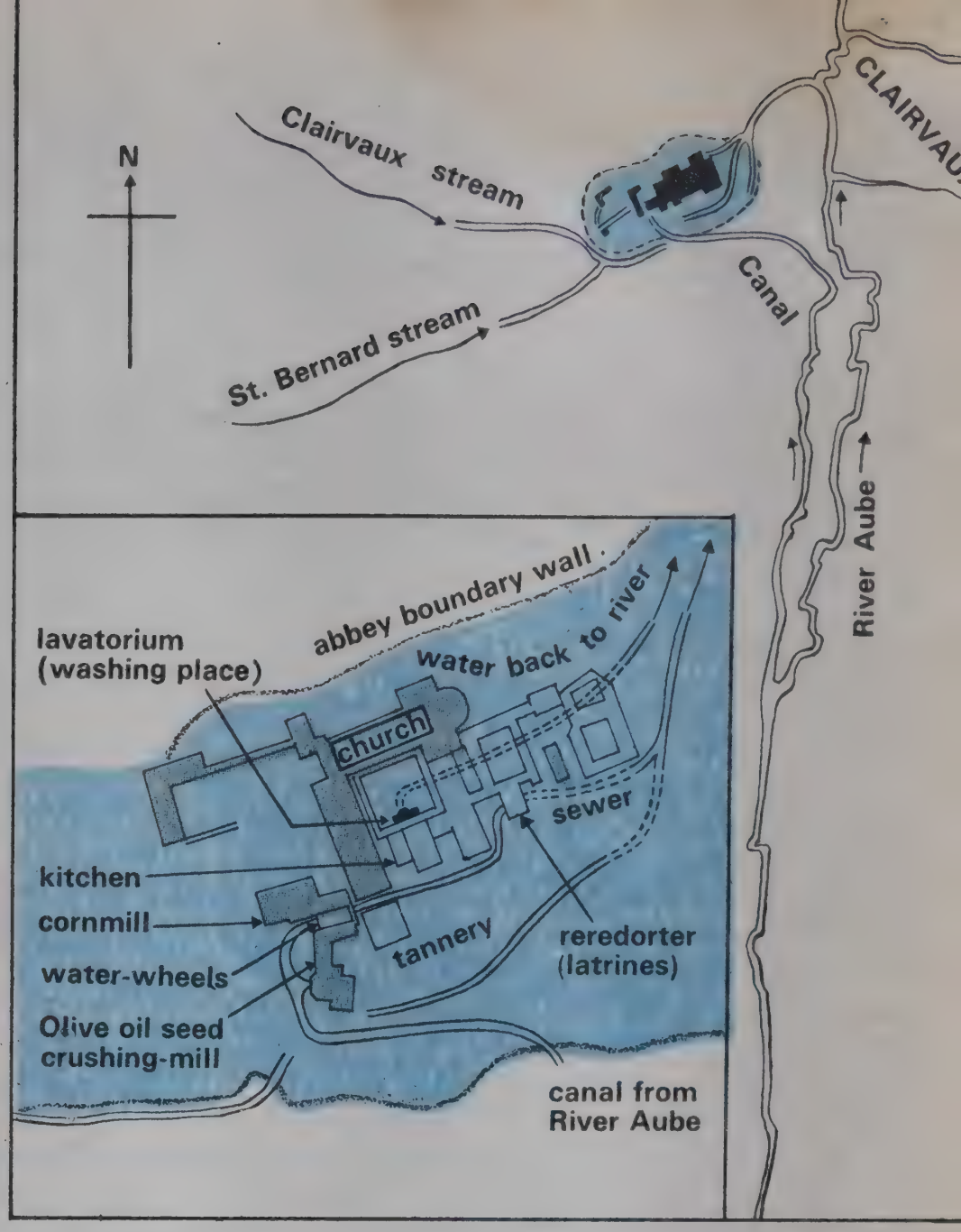
A: Gothic buttresses (13th century). (Drawing by Villard de Honnecourt)

B: Construction-lines for drawing a man's face (by Villard de Honnecourt, 1235)

C: Construction-lines used in designing the Westminster Abbey, 1245



Protestantism and Puritanism in the economic growth of the West are well-known. However, Pacey points out that whatever factual truth there may be in these views, the emotional and religious commitment to the work-ethic did not certainly originate with Protestantism. Its roots go very much farther back. It was certainly revived by Martin Luther's doctrine of 'the priesthood of all believers', and provided a framework for initiating action at the level of the ordinary people. But the real origins of the work-ethic must be traced to the life-style for Christian monastic orders laid down by St. Benedict around AD 530. The Rule of St. Benedict prescribed five and a half hours of manual work each day for each monk, thus giving a religious sanctity to work of this nature. In the next 500 years, monastic life lost much of its discipline and religious fervour for manual work, till in the 11th and 12th centuries there was a great wave of enthusiasm to reform Benedictine monastic life and restore to it some of its original austerity. Several new monastic orders were formed, one of them being the Cistercians. This order grew into a highly dynamic community under the leadership of St. Bernard of Clairvaux.



Plan of Clairvaux Abbey and the water supply system developed by the Cistercian monks (AD 1136). The new buildings site (coloured portion) had been shifted about 400 metres away to the east from the original site so that water from the river Aube could be used (via canal) to supplement the flow from the two small streams

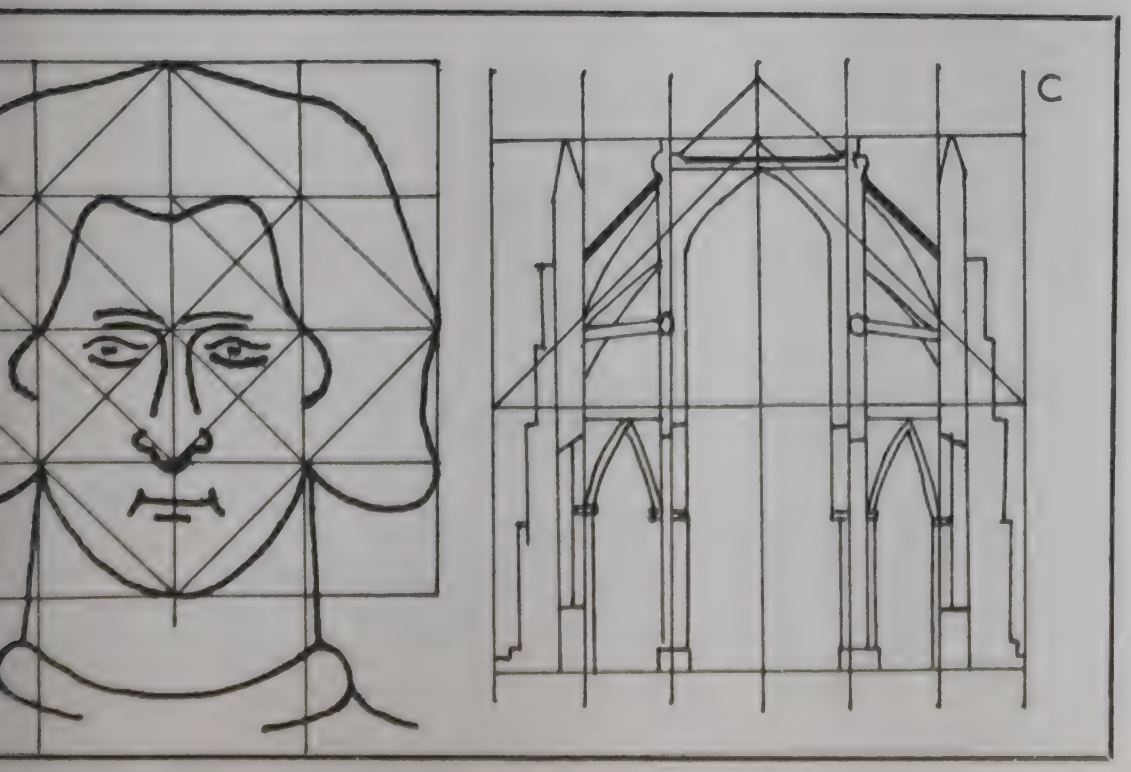
The Cistercian abbeys (there were more than 300 of them in Europe by the end of the 12th century) played a very important role in the development of craft technology and in the dissemination of technical information on a wide variety of mechanical arts all over Europe and England. Pacey points out that St. Bernard's revival of St. Benedict's emphasis on manual labour was of considerable importance in building up the technical competence of the Cistercians to a high level. In Pacey's words, St. Bernard taught that, " labour should play an important part in the life of a monk alongside intellectual effort and religious devotions.. . . . Just as men had an obligation to think and pray, so also they had an obligation to do manual work. *It was perhaps natural in this context that monks should think about the techniques they used in the course of their work and endeavour to improve them* " (emphasis added).

The early innovations in the Gothic style of cathedral architecture (pointed arches, rib vaults, flying buttresses) were Cistercian in origin. Some of the more famous early cathedrals built incorporating this new building technology were: Abbey Church of St. Denis (1130–40), Canterbury Cathedral rebuilt in 1174, Notre Dame Cathedral begun in 1163. In the course of the next several decades, the high Gothic style became perfected resulting in such examples as: Chartres (1194), Rouen (1200), Rheims (1211), and later still, the rebuilt Westminster Abbey (1245) and Cologne Cathedral (1248).

The Cistercian monks in England played an important role in the revival of furnace techniques to smelt iron-ore and in the development of iron-making. In their abbeys they were highly innovative in harnessing water-power to carry out a variety of technical and domestic tasks. "At Clairvaux, for example, the river drove corn-mills, worked a fulling-mill and tannery and various crushing-mills, as well as supplying the kitchen and washing places, and flushing clean the latrines" [Pacey].

Agriculture was another area in which the Cistercian technical contribution was of a high order. They were instrumental in bringing vast areas of virgin land into cultivation since it was their practice to locate their abbeys far away from built-up areas and developed regions. In England, the growth of sheep-farming and wool-manufacture owed a great deal to Cistercian initiatives.

Unfortunately, the high religious emphasis placed on manual work in the early monastic orders slowly died down. Thomas Aquinas, in the 13th century, finally seems to have given a doctrinal sanction to devaluing manual work by the monks by arguing:



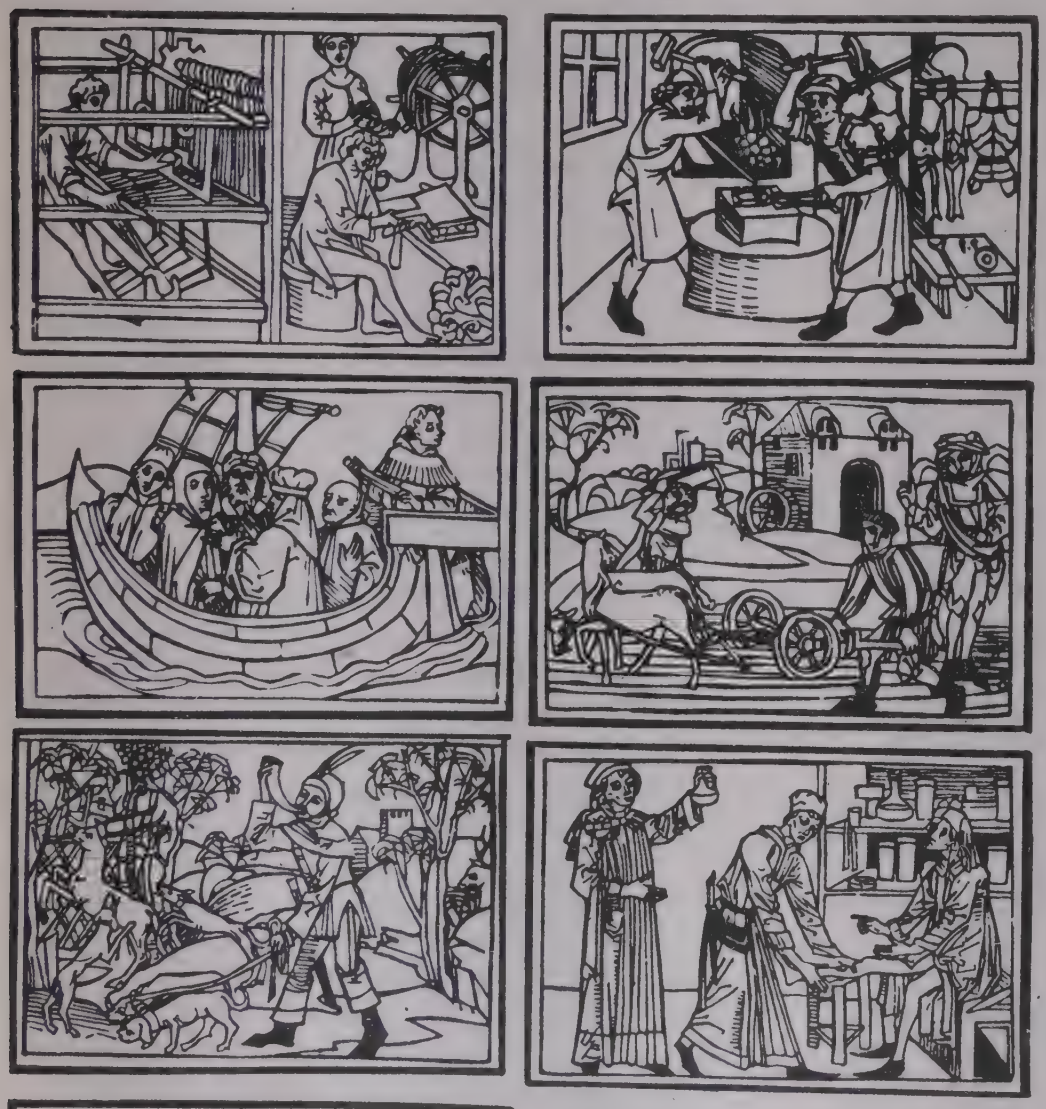
"If a man could support life without food, he would not find it necessary to work with his hands; the same applies to those who have other legitimate means of livelihood. In so far, however, as handwork is performed to overcome idleness or to mortify the body, it does not itself come within the scope of a command, since the body can be mortified and idleness can be overcome by many methods other than handwork. . . . If, therefore, nothing in their Rules enjoineth any special handwork, then are members of the Order no more bound to execute handwork than are those in the outside world" [from Klemm].

In the late 12th century, systematic efforts were made to teach the mechanical arts in the schools attached to the great cathedrals along with the Seven Liberal Arts inherited from the late Roman times. Hugh of St. Victor, a German who became the Director of the School of St. Victor in 1133, attempted to provide a 'theological' underpinning for the teaching of the mechanical arts by dividing them into seven branches: Weaving, Weapon-foundry, Navigation, Agriculture, Hunting, Medicine and Drama, and argued, "Of these, three are related to the external equipment of Nature, by which Nature protecteth herself against injuries; four are related to the inner equipment, that by nourishment and nurture she may grow and prosper. Thus there is a definite similarity to the Trivium and the Quadrivium; since the Trivium (Grammar, Dialectic and Rhetoric) is concerned with the designation of words, a somewhat superficial matter, while, on the contrary, the Quadrivium (Arithmetic, Geometry, Astronomy and Music) deals with ideas which are inwardly grasped. . . " [from Klemm].

An important factor in the development of the mechanical arts in the 12th and 13th centuries was the high regard given to mathematics. At the school attached to the Chartres Cathedral, the great interest taken in Plato's works was a direct stimulus to the teaching of mathematics. The great age of Gothic architecture coincided with the rediscovery of Euclid's geometry in Latin translation from Arab sources. Euclid's theorems were first taught at the Chartres school.

These Cathedral schools, from which the universities evolved later, often enrolled young persons who were training themselves to become skilled craftsmen. Pacey writes: "Such were the architects of the cathedrals — literate men who knew Latin and who were capable of keeping in touch with academic geometry; they were the men who could write about mensuration and surveying. One anonymous French author of the 13th century described methods used by masons for finding the areas of triangles, octagons, and circles." It has been argued by historians of cathedral architecture that the spatial proportions of the great Gothic cathedrals were worked out using geometric constructions.

The two centuries from 1150–1350 saw a very rapid growth of technology in Western Europe and, as we have seen, the monastic orders and, later, the cathedral schools played a decisive role in building up this technological base. The next hundred years were lean ones for Europe as far as technological innovations were concerned. From 1450 onwards again, with the start of the Renaissance, scientific and technical activity began to gather momentum. But now the impetus for discovery and innovation was provided increasingly by public works, trade and commerce, and State patronage. It was in the late 17th and the 18th centuries that we find again a great enthusiasm for democratic reforms in the educational sphere to bring together the academicians and artificers. The effects of this move are most persuasively seen in the Industrial Revolution in England.



The seven mechanical arts, by Hugo von St. Victor: 1. Weaving; 2. Weapon forging; 3. Navigation; 4. Agriculture; 5. Hunting; 6. Medicine; 7. Acting (Woodcuts from Rodericus Zamorensis, Speculum humane vite. Augsburg: Zainer, 1475)

3. Science and technology in the Industrial Revolution

"A revolution in the method of production in one sphere of industry involves a similar revolutionary change in every sphere. . . . Thus, machine spinning made machine weaving necessary; and both together necessitated a mechanical and chemical revolution in bleaching, printing, and dyeing. In like manner, on the other hand, the revolution in cotton spinning made essential the discovery of the cotton gin for the separation of the seeds from the cotton fibre, for only then could the production of cotton reach the proportions which were now indispensable. The revolution in the method of production in industry and agriculture likewise necessitated a revolution . . . in the means of communications and transport . . . by a system of river steamships, railways, ocean steamships, and telegraphs. . . . But, now, vast quantities of iron had to be welded, cut, bored and shaped. For this, in turn, huge machines were required. . . . The machine itself had to produce machines by machines. . . . The most essential condition [to accomplish this] was a machine to supply power to any extent and under perfect control. This already existed in the steam engine. But it was still

necessary to gain the power of producing by machinery the perfectly accurate geometric forms required for the separate parts of machines: straight lines, planes, circles, cylinders, cones and spheres. This problem was solved by Henry Maudsley in the opening years of the 19th century by the invention of the slide-rest. . . . This mechanical appliance does not replace another tool, but the human hand itself. . . . Thus, it became possible to produce the geometrical forms requisite for the individual parts of machinery with the degree of accuracy, ease and speed that no accumulated experience in the hand of the most skilled workman could give. . . . "

Thus, Karl Marx perceptively analysed the revolutionary aspect of the Industrial Revolution. A consideration of the conceptual aspects of the technological changes that were taking place at this time would show that in the Industrial Revolution we see the first beginnings of the transformation of artisan-based technology to science-based technology. In this sense, it is the start of the modern era when technology increasingly tends to derive directly from academic science. It should be of interest, then, to ask what were the relative roles played by the artisans and the academics in bringing about the Industrial Revolution? Contrary to what we might have been led to believe on the basis of our modern prejudices, historical studies tend to show that the initiative for effecting this transformation from artisan-based to science-based technology did not originate from academic scientists but from artisan-engineers and engineer-entrepreneurs, who had sufficient understanding of science and who were keenly aware of the relevance of science to bring about this change. Our immediate concern, here, is with the social and institutional forces that were responsible for the diffusion of scientific knowledge to these non-academic 'fabricators and implementors'.

Let us first consider briefly the professional and intellectual backgrounds of some of the individuals who were directly responsible for the revolutionary technological changes that Marx mentions in his analysis.

The Newcomen engine which was the direct ancestor to Watt's steam engine was invented around 1695–1700 by Thomas Newcomen, an ironmonger and blacksmith, and John Cawley, a plumber. Their design was based on earlier work done by von Guericke in Germany, and by Huygens and Papin in Paris. There has been much speculation about how Newcomen knew about these

Smithy with water-driven hammers (Woodcut from Spechtshart, Flores Musicae, Strassburg, J. Pruss 1488)

results and whether he knew about them at all. It is known that Newcomen used to correspond with the members of the Royal Society in London, especially with Robert Hooke. It is presumed that either from these or other private sources he might have kept himself well-informed about developments in this area.

James Watt was the son of a carpenter and merchant, and was educated at the local grammar school where he showed a talent for mathematics. After working for some years as an apprentice to his father, he came under the influence of Dr. Joseph Black of Glasgow University, who was the inventor of the concept of latent heat and was one of the most renowned chemists of his day. Later, when Watt shifted to Birmingham, he came into close contact with many of the distinguished scientists of that time. He helped Joseph Priestley in his experiments leading to the discovery of the constitution of water.

Some of the individuals involved in the mechanisation of the textile industry were self-taught, while some of the others, although closer to the intellectual society of their days, worked closely with skilled mechanics in transforming their ideas into hardware. Samuel Crompton who invented the mule was the son of a skilled craftsman and taught himself mathematics by attending evening classes. Eli Whitney, an American, who invented the cotton gin, was educated at Yale and was part of the intellectual society of New England of his day. He is best known as the inventor of mass production techniques based on interchangeable parts. Dr. Edmund Cartwright, the inventor of the powerloom, was a Fellow of Magdalene College, Oxford. Lacking any knowledge of machinery, it is said, he sought the assistance of experienced workmen to translate his ideas into a reasonable working model.

Henry Maudsley started work in 1783 at the age of 12. Aside from his accomplishments in machine tool technology, he was keenly interested in science. Astronomy and making of telescopes for his own use were his hobbies. He was a close friend of Faraday who used to visit his works frequently.

Not only many of the inventors but many of the scientists of the 19th century were also self-taught. This was true of Faraday, Wheatstone and Davy, among others. Self-education was a highly valued virtue in that age and abundant facilities existed to improve one's scientific, intellectual and professional background, if one wanted to.

Mechanics' institutes or similar organisations were common and books enjoyed very wide sales. Much of the scientific knowledge that had been accumulated by men like Faraday, Helmholtz, Henry, Davy, Black, Priestley, Dalton, and others, were readily accessible to the general public. (Faraday's book *Electrical Researches* was the bible of Edison during his early years.)

For the more professionally inclined, science periodicals were available. The Royal Society began to issue its *Philosophical Transactions* in 1665 providing a source of information on the work of the leading British scientists. In America, the first scientific periodical seems to have been the *Transactions of the American Philosophical Society* which began publication in 1771.

There were many organised and individual efforts at popularising science. Benjamin Thompson, Count Rumford, floated a proposal in 1799 to found a public institution by subscription " in the metropolis of the British Empire for diffusing the knowledge, and facilitating the general introduction, of useful mechanical inventions and improvements ". The result was the Royal Institution which, from 1851 onwards, has been arranging science lectures with demonstrations for the general public. In the United States, the Franklin Institute was founded in 1824 and the Smithsonian Institution in 1846. The Franklin Institute was intended to be a meeting place for tradesmen, businessmen, and scientists, to discuss the practical applications of science and to encourage science by making awards to inventors.

Many popular science journals were started in this era: for example, in England, *Nicholsan's Journal* and

Mechanics' Magazine. *The Engineer* was founded in 1856. Professor Silliman of Yale started the *American Journal of Science* in 1818 which was the first national science journal in America. Its object was to provide general scientific information for the use of scientists and others. By its influence in the era leading up to the Civil War, it did much to assist the growth of American science. The *Popular Science Monthly* was founded in 1872 and was widely read by amateur inventors who thrived during and after the Civil War.

Apart from the variety of books on several specific subjects, many encyclopaedias and dictionaries were published at this time. These discussed mechanical processes and machines, often illustrating them with drawings. These were often published in parts so that they could be within the financial means of the artisans for whom they were intended.

To those who could not afford to buy these publications, there were the public libraries. Chetham's Library in Manchester was started in 1653 and Dalton found this library of great assistance in his work. A subscription library was founded in 1792 by the Manchester Reading Society.

Again, in the second half of the 18th century, in England, popular science lectures given by itinerant lecturers — some nationally famous — were very common. The contribution of these itinerant lecturers to the diffusion of general scientific knowledge in the country has not yet been fully appraised. Several of these lecturers took with them on their tours quite elaborate working models and scientific apparatuses for demonstration. In addition, they usually published their lectures in book form or at least printed and sold synopses of their lectures. These were priced so as to be readily accessible to the ordinary public, mechanics and other artisans.

Many of these itinerant lecturers kept closely in touch with the researches of the best scientists of their day, and were outstanding popularisers of science. From available historical records it can be ascertained that in their popular lectures they covered topics such as: the nature of matter, laws of motion, mechanics, projectiles and pendulums, hydraulics, pneumatics, heat, pyrometry, optics, light, colour and astronomy.

These itinerant lecturers were varied in their educational backgrounds. Some were almost wholly self-educated. Several others had degrees from Scottish universities where scientific work was most thriving at that time. Musson and Robinson, from whose book many of these details have been taken, quote Dr. Brewster, a biographer of James Ferguson, one of the successful itinerant lecturers, as saying that to the lectures of Ferguson and others like him " we must attribute the general diffusion of scientific knowledge among the practical mechanics of this country, which has in a great measure banished those antiquated prejudices, and erroneous maxims of construction that perpetually misled the unlettered artisan ". Dr. Brewster also noted that Ferguson's books " were widely circulated among all ranks of the community. We perceive them in the workshop of every mechanic".

Another characteristic feature of the late 18th and early 19th centuries in England and America was the large number of Literary and Philosophical Societies (' Philosophical Clubs ') that grew up and thrived not only in national capitals like London and Philadelphia, but in numerous provincial towns like Manchester, Birmingham, Leeds, Newcastle, Norwich, Derby, and in America, Boston and New Haven. It is only in recent years that historians of technology have begun to study systematically the constitution and activities of these Philosophical Societies. One of the most famous and most influential of these Societies was the Lunar Society of Birmingham. To understand the role played by these informal gatherings in the diffusion of scientific knowledge in the 18th and 19th centuries, it is perhaps useful to consider the activities of the Lunar Society briefly.

The Society met every month on the Monday nearest the full Moon (and hence the name Lunar Society). It kept no record of its deliberations, nor did it publish any proceedings of its activities. (The activities of the Society have been reconstructed by historians from indirect sources like letters, memoirs and so forth.)

The membership of the Lunar Society included: Mathew Boulton, Josiah Wedgwood and James Keir who were three of the most successful industrialists of that age; R. L. Edgeworth, a well-known educationist; Thomas Day, a very successful children's book writer; Erasmus Darwin, the grandfather of Charles Darwin and a botanist; James Watt, the most famous engineer of the Industrial Revolution; and Joseph Priestley, one of the most renowned scientists of that time.

The Society flourished from about 1770 to the end of that century. The intellectual and practical interests of the members of the Lunar Society seems to have ranged over the entire spectrum of problems and potentialities of industrialisation: " transportation, finance, supply of power and raw materials, education, politics, community improvement and business organisation. . . . The most characteristic function of the Society, however, was the combination of technological innovation with scientific investigation. . . . The Lunar Society constituted an informal industrial research establishment in which science and technology were regularly and deliberately cross fertilised " [Schofield].

Studies of the activities of the Lunar Society and similar societies that grew up and thrived influentially in the midlands and northern towns of England show that the interaction between scientists, technologists, engineers and industrialists played a significant role in bringing about the changes in the structure and functioning of society which in their totality amounted to the Industrial Revolution.

There was much interaction between visiting Americans and members of some of the philosophical societies of England. Benjamin Franklin, for example, was a good and close friend of the Lunar Society members. Franklin was one of the founders of the American Philosophical Society in Philadelphia in 1743. After the Revolutionary War, Franklin assisted in constructing a permanent hall for the Society and acted as its president till his death. After the Revolutionary War, Academies of Arts and Sciences were founded in many cities in America ; those in Boston and in New Haven, founded in the late 18th century, were perhaps the most important of these.

4. Relevance of history to current problems

The work-ethic of the 11th and 12th century monastic orders — Cistercians, in particular — and the historical details about the diffusion of science among the artisan-engineers and entrepreneurs during the Industrial Revolution bear out, I think, rather convincingly my earlier-outlined thesis that the development of a technological culture is decisively dependent on a complex and intimate relationship at the working-level between ' thinkers ' and ' fabricators ' or ' implementors '. And in promoting this relationship, a high regard in the society for ' manual work ' and the role of middlemen functioning as bridge-builders between these two groups are of fundamental importance.

In India, typically, both these factors have been non-existent. And, if my thesis is valid, that could to a large extent explain the puzzle we started out with. Analogous explanations could hold for China, although

Organised R & D and Independent Inventors

In the 20th century technological innovation intimately depends on scientific sophistication of a very high order. Because of this, one may be tempted to assume that the lessons of history are not of immediate relevance. But there is no justification for such an assumption. Despite the efforts to organise and systematise the process of making inventions through the establishment of large industrial and governmental R & D laboratories, studies of inventions show clearly that the independent inventor, working outside the framework of established laboratories, still plays a seminal role. Studies of various major 20th century inventions indicate that only a small proportion of these came from laboratories of large corporations.

J. Jewkes and his colleagues in their important, and by now classical, study, *The Sources of Invention*, have considered in detail the origins of 63 important inventions of the recent past. They have determined that over one-half of these were the result of pioneering work carried out by individuals with little or no institutional support. In this category come the following cases: Air Conditioning; Air Cushion Vehicles; Automatic Transmissions; Bakelite; Ball-point Pen; Catalytic Cracking of Petroleum; 'Cellophane'; Chromium Plating; Cinerama; Cotton Picker; Cyclotron; Domestic Gas Refrigeration; Electric Precipitation; Electron Microscope; Gyro-compass; Hardening of Liquid Fats; Helicopter; Insulin; Jet Engine; Kodachrome; Magnetic Recording; Moulton Bicycle; Penicillin; Photo-typesetting; 'Polaroid' Land Camera; Power Steering; Quick Freezing; Radio; Rhesus Haemolytic Disease Treatment; Safety Razor; Self-winding Wristwatch; Streptomycin; Sulzer Loom; Synthetic Light Polariser; Titanium; Wankel Engine; Xerography; Zip Fastener.

Innovations that have come out of the efforts of industrial research laboratories are: Acrylic Fibres; 'Cellophane' Tape; Chlordane, Aldrin and Dieldrin; Continuous Hot-strip Rolling; Crease-resisting Fabrics; DDT; *Diesel-electric Locomotive;* Duco Lacquers; *Float Glass;* Fluorescent Lighting; *Freon Refrigerants; Methyl Methacrylate Polymers;* Modern Artificial Lighting; *Neoprene; Nylon;* Oxygen Steel-making; *Polyethylene; Semi-synthetic Penicillins; Silicones;* Synthetic Detergents; *Television;* Terylene; *Tetraethyl Lead; Transistor.* The italicised inventions either originated or were developed for commercial exploitation in really large industrial laboratories. The rest were from much smaller firms.

Jewkes et al note that " even where inventions have arisen in the research laboratories of large firms, the team responsible for it seems often to have been quite small. It is usually found that one outstanding figure has been surrounded by, and has stimulated, a few devoted colleagues in an intimate relationship with his manner of thought and speculations".

These findings would seem to indicate that one does not have to go to the distant past to learn from history.

R. N.

the issues involved there might be more complex. In any case, my principal objective is not so much to worry about the absence of these factors in historical times in India, but to voice my concern about their continued absence now.

I think it is important for us today to learn from history that technological revolutions are brought about, not by academic scientists, but by artisan-engineers and engineer-entrepreneurs. Quite often these innovating individuals are non-conformists and dissenters. And it is important to make available means for such persons to acquire scientific and technological knowledge through informal and semi-formal channels. Academic scientists can and must play a significant role in catalysing the innovative potentialities of these individuals. Frameworks for informal and semi-formal diffusion of scientific and technological principles and practices are as important as, and in some cases perhaps more important than, frameworks for formal science education in the third world countries which are concerned about industrialising and technologically revolutionising their societies.

It is significant to observe that in the way educational and extra-curricular/professional interactions are structured at present in our country, we do not have the equivalents of either the 'dissenters' academies' or the 'philosophical clubs'. Academicians hardly ever come into intellectual contact with artisans; nor do they come into intellectual contact with non-academic innovators in industry and other implementation-oriented spheres. Part of this problem stems from our highly class-conscious social structure. Part of this problem also stems from the fact that the institutionalisation of academic science in our country is patterned after that prevailing in the West *now* rather than in the 17th or 18th centuries. On the other hand, the technological culture of our country at present is possibly less sophisticated than what was the case in the West in the 17th and 18th centuries. This mismatch in the science and technology background between the academic and artisan/entrepreneurial cultures tends to push apart, rather than pull together, 'academicians' and 'fabricator-implementors'. I think this points out the urgent need for bridge-builders, bridge-building activities and bridge-building institutions. History can certainly teach us what is possible to accomplish in this area.

The spirit in which this article has been written is very aptly summarised by some remarks attributed to Sir Alex Smith, Director of the Manchester Polytechnic. He is reported to have suggested that the expansion of full-time degree courses and economic decline in the UK, while not necessarily connected, could be attributed to the same underlying cause:

> " to the lack of esteem given to skills in doing, making, designing, developing and manufacturing, compared with the high esteem given to academic study and scholarship, to analysis and to research as the proper pursuit of the ablest minds. We have created two cultures, not so much in the sense that [C.P.] Snow outlined, but in the sense that cultured, civilised, educated, research-minded people pursue a cultured, civilised, educated, research-minded life, while the process of earning our livelihood as a nation can be carried out by 'others'. It is not a very edifying or stable division."

A Senior Professor at the Tata Institute of Fundamental Research and Director of the National Centre for Software Development and Computing Techniques (at the TIFR), Prof. Narasimhan (51) did his MS in electrical engineering from the California Institute of Technology, Pasadena, USA, and both his MA and Ph D in mathematics from the Indiana University, USA. A computer scientist, his research interests include visual data processing, programming language theory, models of language behaviour and application of system-theoretic concepts and techniques to the study of behaviour and behavioural sciences. Fellow of the Indian Academy of Sciences and also the Indian National Science Academy, he was also awarded the Jawaharlal Nehru Fellowship for 1971–73. *Recommends reading:* **1.** Klemm, Friedrich 1954/1959 *A History of Western Technology.* George Allen & Unwin. **2.** Voice of America Forum Lectures 1968. *History of Science.* Higginbothams, Madras (for R. E. Schofield). **3.** Jewkes, J. et al 1969 *The Sources of Invention.* MacMillan. **4.** Musson, A. E. & Robinson, E. 1969 *Science and Technology in the Industrial Revolution.* Univ. Toronto Press. **5.** Pacey, Arnold 1976 *The Maze of Ingenuity, Ideas and Idealism in the Development of Technology.* MIT Press. **6.** Wilby, Peter 1976 The outdated university tradition, *New Statesman* (21 May) (for Sir Alex Smith).

OF VIRUSES AND JAUNDICE

M. V. N. SHIRODKAR
N. G. CHANDERKAR

And David's Lips are lock't; but in divine
High piping, Pehlevi, with "Wine! Wine! Wine!
Red Wine!"—the Nightingale cries to the Rose
That yellow Cheek of hers to 'incarnadine...

Yellow cheeks had been known to represent illness long before Omar Khayyám wrote those lines, but the twentieth century reader could read an irony in that eleventh century quatrain: that alcohol, taken in moderation, may lend a healthy suffusion of pink to one's cheeks, but consumed *ad libitum*, it can lead to hepatitis or inflammation of the liver (or even cirrhosis), and hepatitis can bring that sickening yellow colour to the skin and the whites of one's eyes. We call it jaundice.

The term jaundice comes from 'jaune', the French word for yellow; the scientific name is 'icterus'. It is a characteristic lemon-yellow pigmentation of the bodily tissues, especially of the sclerae (the whites of the eyes), due to excessive accumulation of bilirubin, or bile pigment, in the serum. Bilirubin is produced from the breakdown of haemoglobin of the blood in the reticuloendothelial system. This system comprises the phagocytic elements of the liver, spleen and bone marrow. These phagocytic cells engulf and break down the worn out or diseased red blood cells in the body. When produced in normal amounts, bilirubin is discharged into the blood and excreted by the liver. Now, if the rate of excretion fails to match that of pigment production, bilirubin accumulates in the serum and, ultimately, stains the tissues, giving rise to clinically apparent jaundice.

What causes jaundice? It must be made clear that jaundice is a sign. Its origin can be compartmentalised, according to location, as *hepatic*, *post-hepatic*, or *pre-hepatic*; at the same time, to simplify, we could also classify the causative agents as physical, chemical and biological.

In hepatic jaundice, the liver cells themselves cannot competently excrete the bilirubin, which is being produced at a normal rate. This occurs in the case of the 'biological' causes like viruses and the 'chemical ones' like the toxic action of drugs such as alcohol or chloroform which damage the liver cells, lead to inflammation and interference with the normal bilirubin excretory function of these cells and, thus, to jaundice. The well-known role of excessive alcohol consumption in repeated liver cell destruction and scar-formation (cirrhosis) is a case in point.

In post-hepatic jaundice, there is mechanical obstruction to the passage of bile through the biliary transport apparatus. An example of such a 'physical' category is obstructive jaundice, which may be produced by a tumour of the head of the pancreas, or by a stone in the bile duct, which impedes the normal flow of bile from the gall bladder into the duodenum. Should the impediment be serious, the bile will 'back up' into the circulation and the excess bile pigment produce jaundice.

In pre-hepatic jaundice, the excretion of bilirubin by the liver is normal, but the *production* of bilirubin is excessive, over and above the capacity of the liver to excrete it. Examples of jaundice, due to excessive bilirubin production following excessive haemoglobin breakdown, are the various haemolytic anaemias, but, in particular, a condition called neonatal jaundice (see box on p. 22).

The normal human liver — microscopically . . .

The microscopic, routinely visualised structure of the normal human liver (Fig. 1) is as follows: the histological unit is a lobule consisting of liver cells (hepatocytes) which make up the parenchyma which carries out the normal hepatic functions. The liver is made up of innumerable such lobules, separated from one another by delicate fibrous strands. At the centre of each lobule lies the central vein, a branch of the hepatic vein, whilst at the periphery, lying within the fibrous strands, are a few portal triads. Each triad consists of an arteriole (a branch of the hepatic artery), a vein (a branch of the portal vein) and a biliary ductule. The hepatocytes are arranged in plates one cell thick. These radiate from the central vein to the periphery of the lobule, constituted by the portal triads; the plates form an intricate labyrinth, the space of which is occupied by thin-walled blood-carrying channels called sinusoids. These are lined by large phagocytic cells belonging to the reticuloendothelial system and called the Kupffer cells. The sinusoids drain blood from the portal vein and the hepatic artery into the central vein. The bile secreted by the liver cells is carried by means of a series of very tiny channels, known as bile canaliculi, to the periphery of the lobule and drain via the biliary ductules into the bile duct. To maintain the structural integrity of the parenchyma, the cells have to be anchored to a scaffolding known as the reticulum which is made up of a fibrous protein called reticulin. This cannot be seen in the normal routine liver section because it does not take up the usual stain.

Fig. 1 Photomicrograph of normal human liver (x84). A typical liver lobule can be seen. Arrow 1 shows a central vein, while arrows 2 show the portal triads which partially limit the liver lobule. Radial arrangement of liver cell (parenchymatous) cords, separated by sinusoids can be clearly seen

Infective hepatitis

When it comes to the biological causes, the most important causative agents behind hepatitis (and hence jaundice) are viruses. And that brings us to the most common form of this disease — *infective hepatitis*. In this context, clinicians choose to differentiate between ' infective hepatitis ' and ' viral hepatitis ', the former being a wider term, encompassing not only viruses, but also all *other* biological causative agents.

Viral hepatitis is caused by at least two small viruses — A and B, and in restricted localities, the C virus. The C type of hepatitis has recently been recognised as being clinically indistinguishable from A or B, but immunologically different. In some areas of the world, it is now the most common form of hepatitis *following blood transfusion*. The predominant manifestation in these viral forms is hepatocellular necrosis which means death of liver cells. The other viruses which are known to produce hepatitis in the neonatal and perinatal periods are rubella (German measles), cytomegalovirus, herpes simplex, chickenpox, influenza, measles and smallpox.

Besides viruses, two prominent causative agents behind infective hepatitis are bacteria and protozoa. An example of bacterial hepatitis is leptospirosis, or Weil's disease (the disease is caused by a spirochaete, *Leptospira icterohaemorrhagiae*, and is transmitted through the urine of an infected rat). Congenital infection with *Treponema pallidum*, the spirochaete of syphilis, can also produce jaundice in the neonate. Examples of protozoan hepatitis agents are *Toxoplasma* and *Entamoeba histolytica*. *Toxoplasma* is an intra-cellular parasite which can cross the placenta and produce neonatal jaundice. *E. histolytica* can produce jaundice following hepatitis in cases of amoebiasis.

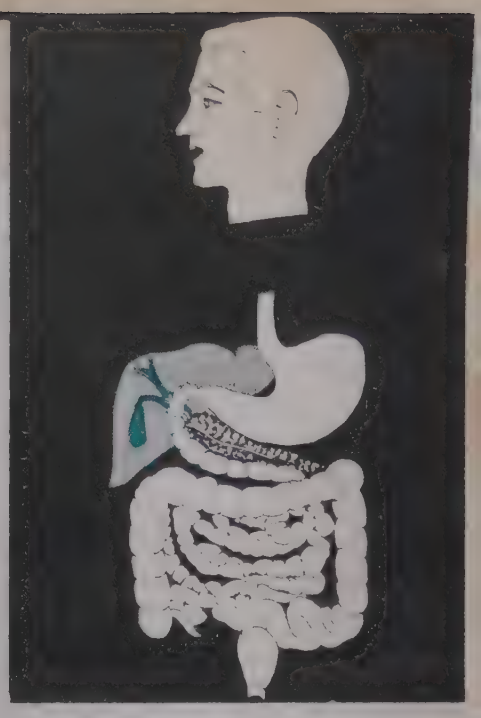
In this article, we shall discuss mainly the viral aspect of hepatitis, an area in which much of the research work is concentrated.

It must be made clear at the outset that, in cases of viral hepatitis, by no means do all patients develop the lemon-yellow tint of the sclerae — the visible sign of jaundice. For every proven case of jaundice, there are 10 to 20 ' carriers ' who have non-apparent or subclinical infection and it is these people who pose a greater danger to public health, being the potential foci of spread of the virus.

To come back to the patient, he may give a history of contact with another jaundiced patient, or with rats, or admit to addiction to drugs or alcohol. Actually, the patient's intake of alcohol should be very carefully looked into since, as Fig. 2 shows, infective hepatitis can cause greater damage to the liver which has already been damaged by alcoholism. And, travel experience must also be looked into, as certain areas of the world have a very marked incidence of either hepatitis A, B or C or some of the other viruses, such as yellow fever in South America and Africa. (Why it should be so is still an interesting research problem!)

As regards the clinical picture, both in hepatitis A and B, the symptoms are very similar, but more serious in the latter infection. In the usual, clinical form, acute hepatitis resembles flu. In most patients, the pre-jaundice stage lasts three to nine days; the striking features are loss of appetite (anorexia), and dislike towards foods and cigarettes, or *bidis*. Nausea, or even actual vomiting, may occur in the pre-jaundice phase for about three to four days and a dull ache, or pain, under the right rib margin may be felt. A fever of 37·6°–39·4°C may last for two to five days; chills rarely accompany the fever, which subsides with the appearance of jaundice. Skin rashes appear in about five per cent of the cases, especially with hepatitis B, along with joint and muscle pains. Very rarely would a physician consider a diagnosis of viral hepatitis, except in known epidemics, prior to the appearance of the amber-coloured urine. Soon after this stage, the jaundice phase begins, to last for about

COMPARTMENTALISATION OF JAUNDICE ACCORDING TO LOCATION & CAUSATIVE AGENT



I HEPATIC JAUNDICE

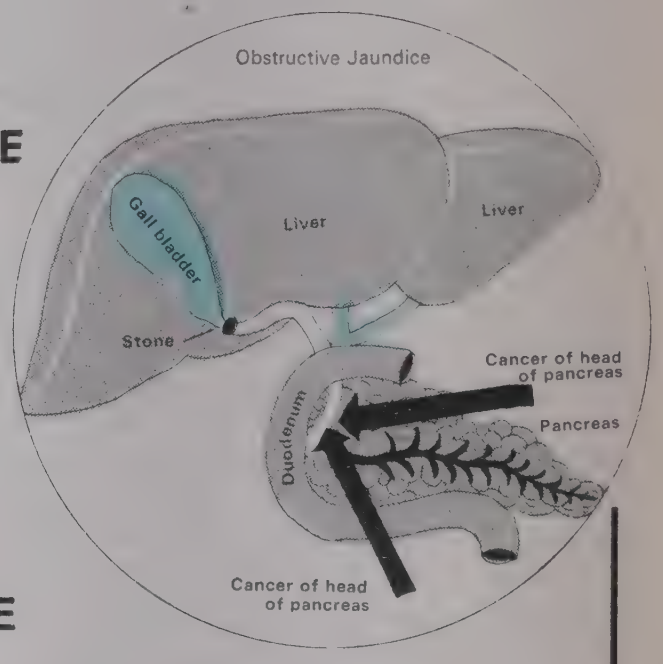
1 Biological Agents
- Viruses (Hepatitis A, B, and others)
- Bacteria
- Protozoa

2 Physical Agents
- Accidental damage to liver
- Irradiation damage during radiotherapy

3 Chemical Agents
- Alcohol
- Chloroform
- Carbon tetrachloride
- Other drugs
- Phosphorus poisoning

II POST-HEPATIC JAUNDICE (Obstruction)

- Stone in biliary tract (bile duct)
- Carcinoma (cancer) of head of pancreas
- Primary carcinoma of liver
- Physiological jaundice of newborn



III PRE-HEPATIC JAUNDICE (Haemolytic Anaemias)

- Blood-group incompatibility (Rh, ABO)
- Glucose-6-phosphate dehydrogenase deficiency
- Other (rare) genetic-based conditions

Normal concentrations of serum bilirubin range from 0·5 to 1·2 mg/100 ml and all the bilirubin is in the free form. By free, or unconjugated, bilirubin we mean the form released by the haemoglobin breakdown; it is less water-soluble and circulates tightly bound to serum albumin. Conjugated bilirubin, on the other hand, is esterified, which means a salt formed with two molecules of glucuronic acid on the propionic acid side-chains, and this is more water-soluble. When a high proportion of bilirubin is in the conjugated form, jaundice is detectable at levels of 2-3 mg/100 ml, for this form of the pigment stains the superficial tissues of the body, such as the sclerae and the skin, much more readily than does free bilirubin.

one to two weeks; further darkening of urine and constipation along with pale-coloured stools occur.

Within a few (8–10) days of the onset of jaundice, the symptoms abate, appetite returns and abdominal discomfort and vomiting cease, pale stools regain their normal colour and jaundice gradually clears. The convalescence phase may last between two to six weeks; general weakness and fatigue may persist longer.

In general, the great majority of the cases recover. The mortality figures range from 0·1 to 1·0 per cent in the case of hepatitis A, and from 1·0 to 10·0 per cent in hepatitis B (the higher mortality figure is seen in cases of hepatitis following blood transfusions). Also, hepatitis B, particularly, may be followed by sequelae, such as subacute hepatitis, chronic active hepatitis which may progress to post-hepatitic cirrhosis, or even to primary carcinoma — in as many as 10 per cent of the affected cases.

In the case of hepatitis A, the incubation period is two to six weeks. The virus enters the body — usually by the oral route — and probably multiplies in the intestinal lining epithelium before spreading through the blood stream to the liver parenchyma. It can be detected in the blood and faeces a week before the onset of jaundice — this is the period when the patient is most infectious for others — and usually disappears after the serum transaminase levels reach their peak.

In hepatitis B, the virus usually enters the body by artificial inoculation of infected human serum (as well as by other routes). The incubation period is longer (six to 24 weeks). The most striking feature of hepatitis B virus is that, in a small proportion of cases, it persists in the serum for months or years, *despite apparent recovery*.

Fig. 2 shows necrosis (cell death) of liver parenchyma in liver biopsy in acute hepatitis A, or B. Usually, one sees focal necrosis within the liver lobule, with characteristic "ballooning" of liver cells, and infiltration by inflammatory cells around the portal triads. In rare cases, a fulminating hepatitis develops and, within days, kills the patient through acute yellow atrophy (massive cell death). In the great majority of acute cases, however, recovery occurs and parenchymal regeneration is completed within three months — the liver cells have extraordinary regenerative powers!

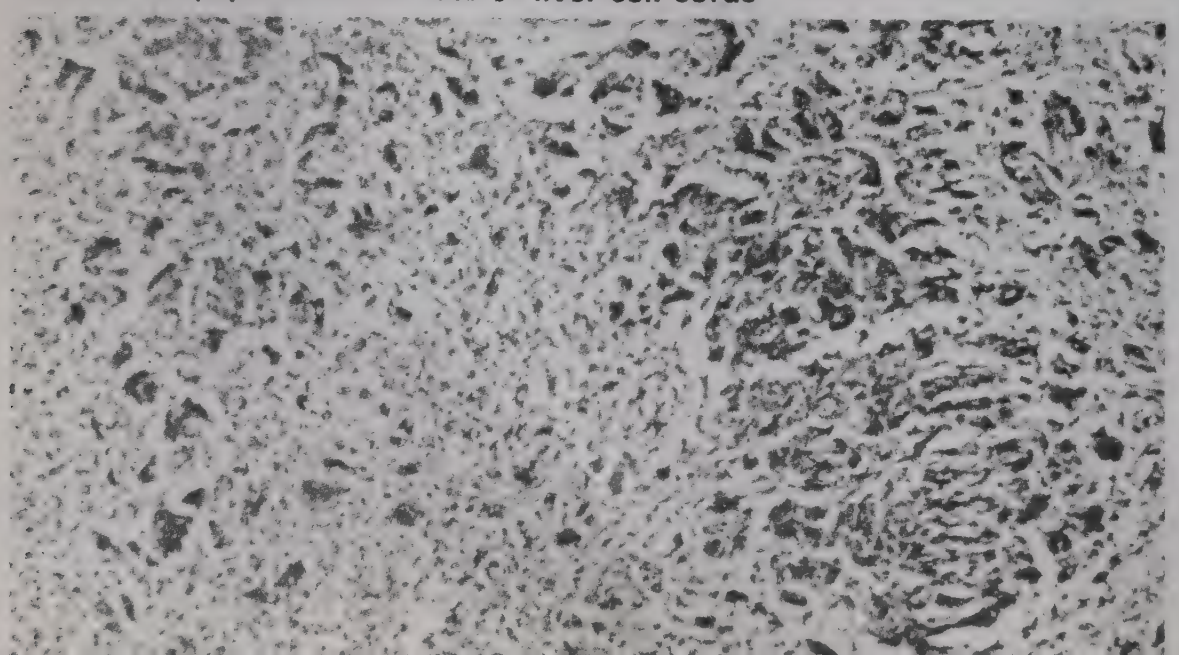
An attack of hepatitis A generally confers long-lasting immunity; however, *second* attacks have been seen in about five per cent of patients, for reasons not yet clear to us. It should be noted here that there is no cross-immunity between hepatitis A and B. Resistance to hepatitis A and B varies and is particularly low in pregnant and menopausal ladies, in older persons, and, in the higher socioeconomic groups.

How the viruses spread

The epidemiology, or mode of spread, of hepatitis A and B viruses has several interesting aspects for the researcher. Both forms of the disease display a worldwide distribution, though the exact incidence is difficult to assess, because of widely differing surveillance methods. Epidemics of hepatitis A have been described in most countries including India and the disease is endemic in numerous tropical and subtropical areas; these are typically economically developing nations where sanitation and standards of hygiene need improvement. (This is because the main mode of spread of hepatitis A is by the faeco-oral route. It should be emphasized, however, that it can also be transmitted by the parenteral or injection route.)

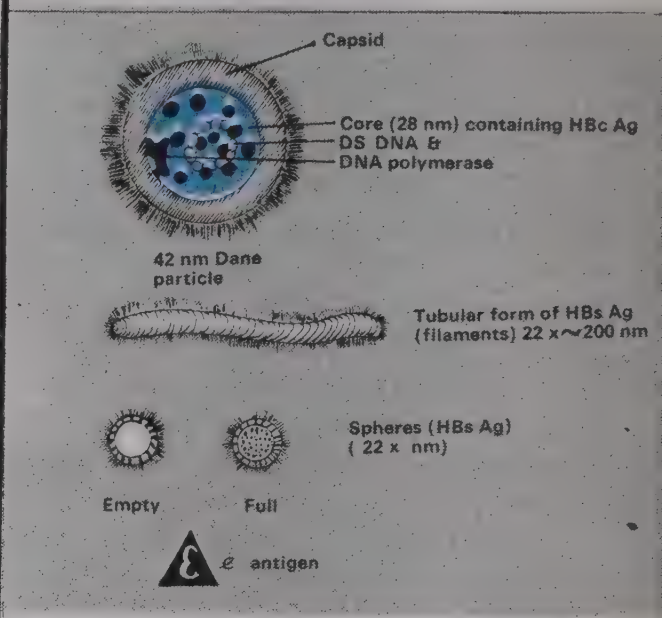
The faeco-oral route is actually how hepatitis A virus is maintained *in nature* by serial transfer (in the absence of major human or animal reservoirs

Fig. 2 Photomicrograph of a human liver showing massive necrosis (acute yellow atrophy) due to viral hepatitis (x84). There is extensive liver cell (parenchyma) loss. One can see sinusoids, and the reticulin framework which is empty due to the loss of liver cell cords



THE VIROLOGY

Let us deal with hepatitis B virus first (designated HBV) since it has been studied more extensively. During acute and chronic hepatitis B infection, several particulate structures, bearing hepatitis B surface antigen (designated HBsAg) are found in the patient's blood (Fig. below). The most numerous of these are the small (22 nm) spherical particles and the long filaments (22 × ~ 200nm), neither of which contain nucleic acid. Also seen is the virion, or the Dane particle — named after its discoverer. This is a 42 nm, double-shelled spheroidal particle which can be separated into a core (28 nm), a 2 nm thick shell and an outer envelope, 7 nm in diameter. Its nucleic acid is a double-stranded circular



DNA with a molecular weight of $1·6 \times 10^6$ daltons. There are several known serological variants, or serotypes of hepatitis B virus. These are defined by different antigenic determinants which can be identified in the outer coat of the virus and the particles. The following are the major determinants: *a*, a group-specific determinant, present in the envelopes of all serotypes; the sub-type-specific determinants *d* and *y*, which are mutually exclusive, allelic alternatives, and another such pair, *w* and *r*. All these are coded by the viral genome, and not by that of the host cell. The practical importance of these sub-types is that since only HBsAg produces neutralising antibodies after HBV infection and, since only the *a* determinant is common to the different serotypes of HBV (the sub-determinants being different), a single attack of hepatitis B will confer lasting immunity only against the same serotype, whereas only partial protection will be conferred against the heterologous sub-types. This raises the likelihood of repeated attacks of hepatitis B in a patient. Furthermore, the same individual is susceptible to hepasitis A virus or C virus. Thus, it is well to remember that, in the preparation of a vaccine against HBV, one should include as immunogens at least those sub-types of HBsAg which commonly prevail in that country, or locality. It is well-known, for example, that the most common sub-type occurring in India is *ayw*, but that a small proportion of Indians possesses sub-type *adw*. On the other hand, in northern Europe, the Americas and Australia, sub-type *adw* predominates.

The core antigen, designated HBcAg, is distinct from the surface antigen and this, the DNA, and a DNA polymerase, which is an important virus-coded enzyme, are inside the core. HBcAg is common to all Dane particles and can be seen by electron microscopy, in the nuclei of infected liver cells, whilst HBsAg is seen, together with Dane particles, in the cytoplasm. Probably, the cores are assembled in the nuclei of parenchymatous cells and acquire their outer coat of HBsAg in the cytoplasm. The presence of HBsAg is clearly shown, staining darkly in the cytoplasm of the liver cells, by the Shikata staining technique, as seen in Fig. 3. The DNA polymerase activity regularly appears in high levels in the blood during the incubation period of hepatitis B, just after the appearance of HBsAg. Chronic HBsAg carriers circulate high concentrations of the small, spherical HBsAg particles in their blood for many years. In most carriers, DNA polymerase activity is low in relation to levels seen during the incubation period of acute hepatitis B.

The most detailed studies on the immune response in hepatitis B indicate that anti-HBc (antibody to the core) rises rapidly and persists only as long as HBcAg is being synthesised, being, therefore, a sensitive sentinel of active infection, since it is the first to appear during clinical or subclinical acute infection and persists throughout the HBsAg carrier state. On the other hand, anti-HBs (antibody to surface antigen) rises only 3–24 months later than anti-HBc, and persists almost indefinitely in about 50 per cent HBV infections. They are the only neutralising antibodies and are, therefore, the best heralds of both past infection and immunity.

In 1972, a new antigen, called the *e* determinant, was described by Swedish scientists. Unlike the *a*, *d*, *y*, *w*, and *r* determinants, which all appear to reside on the same particle, the new *e* antigen appears to be on a different particle. The *e* antigen is found exclusively in sera positive for HBsAg. Antibodies to *e* antigen (anti-*e*) occur frequently in HBsAg-positive sera and in some anti-HBs-containing sera. A recent study has shown that neonatal transmission of HBV occurs commonly from asymptomatic, chronic, HBsAg carrier mothers with *e* antigen in their sera, but not from mothers with anti-*e*. Dane particles were detected in the sera of all mothers with *e* antigen, but in none with anti-*e*. This study suggests that the presence of *e* antigen and Dane particles in the sera of chronic carriers is important for infectiousness of mothers for their newborns.

The heat-stability of HBV is remarkable. A preparation of the virus heated at 60°C for 10 hours still contained live HBV. However, heating at 98°C for one minute destroyed it. This important information has been crucial from the point of view of the preparation of an early heat-inactivated vaccine by Drs. Blumberg and Krugman. In addition, it is most important from the public health standpoint, since it tells us that the ideal method of disinfection is autoclaving, or at least boiling for 10 minutes, where HBV-infected apparatus and materials are concerned.

Hepatitis A virus, abbreviated HAV, is a small virus (25–28 nm), possessing cubic symmetry. As with other viruses of this size, empty and full particles exist. In appearance, HAV resembles the RNA-containing picornaviruses and the DNA-containing parvoviruses. Both full and empty particles are antigenically indistinguishable and aggregate when mixed with serum containing antibody to the HAV. Unlike in HBV, a viral envelope has not been found and subunit components have not been identified. In limited studies, HAV is found resistant to heating at 60°C for one hour, and is inactivated by chlorine (1 mg/ml for 30 minutes). Limited biochemical studies on the staining characteristic of the nucleic acid, with acridine orange, suggest that it may be either RNA, or single-stranded DNA. However, the heat-stability of HAV, and other studies, suggest that HAV is similar to the parvoviruses, which are small DNA viruses. Further studies are, therefore, needed to determine to which, if either, of these two classes of small viruses HAV belongs.

A spectacular aspect of the immune response and the peculiar mode of disease-production by HBV is that, antibodies themselves may contribute to the disease state, certain aspects of which may have, what is called, an *autoimmune* basis. During the pre-icteric stage in the patient, large numbers of intact hepatocytes contain HBcAg, HBsAg and HBV, which can be seen by electron microscopy. Liver damage can result from immune cytolysis (cell destruction mediated through antibody and complement) of liver cells, which are infected sublethally with the virus, through the action of complement-fixing antibodies or sensitised T lymphocytes. Furthermore, antigen-antibody complexes between HBsAg and their antibodies may form and be deposited in the kidneys, arterioles and joints and produce well-known manifestations of serious immune complex diseases, such as glomerulonephritis, periarteritis nodosa and arthritis.

In considering the laboratory techniques utilised for the detection of hepatitis A and B, it must be emphasised that until techniques are developed for the isolation of these viruses in cell cultures, we must rely on liver function and serological tests to distinguish viral hepatitis from other causes of jaundice.

Pale-coloured stools tell us that there is improper excretion of bilirubin into the intestines, which occurs in all types of jaundice, except haemolytic jaundice. However, in severe obstructive jaundice (post-hepatic), the stools may be chalky-white, so that, *after further tests*, viral hepatitis can be ruled out. A raised urinary bile pigment level for detection of jaundice is simple to demonstrate, and is usually positive early in the disease.

But the tests usually considered essential for detecting viral hepatitis fall into two categories: the non-specific and the specific. The non-specific tests of liver function are the serum glutamic oxaloacetic transaminase (SGOT) and the serum glutamic pyruvic transaminase (SGPT). Liver cells participate in a multitude of metabolic activities and, therefore, contain hosts of enzymes. When damaged, they release these enzymes into the circulation, which are then found in excess of normal levels in the serum. This is particularly true of SGOT and SGPT. Rises in their levels provide a sensitive, early index of liver damage.

The specific tests currently utilised for the detection of hepatitis B by research and diagnostic laboratories and blood banks include (in order of sensitivity) counter-immunoelectrophoresis (CIEP), passive haemagglutination, reversed passive haemagglutination (RPH), and the most sensitive, solid-phase radioimmunoassay (RIA). Immune electron microscopy has mainly research applications.

The most recent development in this field has been the enzyme-linked immunosorbent assay technique (ELISA), for HBsAg detection. This technique has a sensitivity similar to that of RIA.

For the detection of HAV and anti-HAV, the techniques used are immune electron microscopy, RIA and immune adherence haemagglutination assay.

Fig. 3 Photomicrograph of a liver from a case of chronic viral hepatitis B stained with a special technique originated by Prof. Shikata of Japan. Some of the liver cells show pale, unstained nuclei surrounded by the darkly stained cytoplasm containing hepatitis B virus and its products

Fig. 4 Photomicrograph of the usual mild form of acute viral hepatitis (x280). The liver cells are enlarged; the cytoplasm is pale and vacuolated (following degeneration)

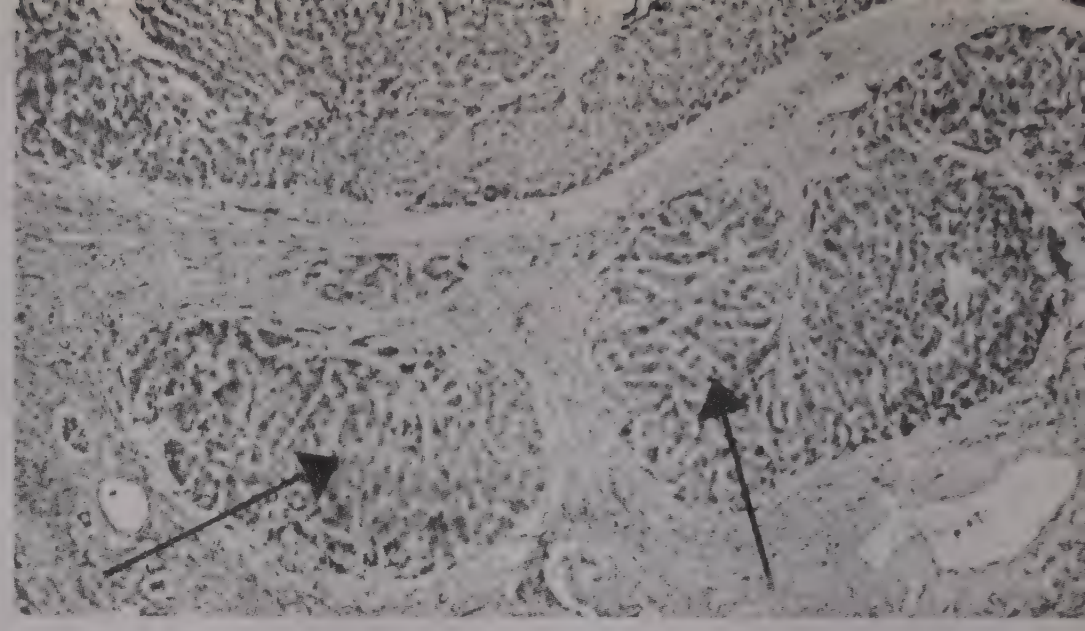


Fig. 5 Photomicrograph of post-hepatitic cirrhosis. Two distinct regenerating nodules (arrows) surrounded by fibrous scarring are evident. Note absence of normal liver architecture (such as central vein and radial arrangement of hepatic cell cords as shown in Fig. 1). The upper portion of the picture shows a very large regenerating nodule

of infection). The serial transfer occurs mainly through close contact in homes, especially where people live under overcrowded and unhygienic conditions. This is also the reason why one can see outbreaks of the disease in institutions for the mentally retarded and during military campaigns! Another reason is that hepatitis A virus is also water-borne, and that may explain its higher prevalence during the monsoon. In New Delhi, during 1955–56, 29,300 hepatitis A cases were recorded when a major water supply system was contaminated by human sewage. In the USA, during 1971–74, 13 outbreaks involving 351 patients were recorded; the cause was the contamination of private or recreational waters with human material.

Numerous food-borne epidemics are well-documented, caused by infected food-handlers' shedding the virus during the incubation period. The source of the outbreak, was possible to detect — usually uncooked food, or food handled after cooking. Another curious mode of spread of hepatitis A is by the ingestion of shellfish grown in polluted waters. Frying of the shellfish destroys the virus whereas steaming does not, because the shells open and the contents may be consumed before the temperature has been raised sufficiently to inactivate the virus.

As regards the age-distribution, in the economically developed countries, hepatitis A occurs at all ages, with about half the number of clinical cases being seen in children below 15 years of age. In tropical and sub-tropical areas, most of the infections are probably acquired in childhood and several of these are subclinical.

The seasonal pattern of hepatitis A is also interesting. In temperate zones, it occurs in epidemic waves, with peaks every 5 to 20 years. In the USA and the Scandinavian countries, it exhibits a marked seasonal variation, peaking in late autumn and early winter. In India, as we have mentioned before, the disease tends to be associated with periods of heavy rainfall. The long-term patterns and trends are not clear, but the figures from several economically developed countries suggest that the incidence of hepatitis A is declining there and that a higher proportion of cases is occurring in adults. Whether this is truly a long-term trend — which would be a most heartening sign — or whether it merely reflects the low point of the current epidemic cycle is yet to be established.

The epidemiology of hepatitis B is even more fascinating than that of hepatitis A. Survival of the hepatitis B virus in man is through the persistent carriers (defined as those showing the presence of hepatitis B surface antigen in their blood for more than six months). And the number of such

JAUNDICE IN THE NEWBORN

Neonatal jaundice can appear as a benign, entirely physiological phenomenon in a great majority of newborn babies. This is an entirely normal occurrence and is due to the breakdown of excess of haemoglobin in the normal newborn (19 grams) to about 14 grams, which is considered to be the normal human level. Almost every newborn baby will develop a serum unconjugated bilirubin concentration of greater than 2 mg/100 ml during the first week of life and this transient hyperbilirubinemia has, therefore, been called " physiological jaundice " in the newborn. Such jaundice, which appears within about 24–48 hours following birth, usually disappears between the sixth and the eighth day.

In contrast, some of the other commoner types of neonatal jaundice, which we may call " pathological neonatal jaundice ", include blood group incompatibilities, glucose-6-phosphate dehydrogenase deficiency and numerous other genetically-based varieties which are much rarer. In these types, jaundice is very severe and does not disappear between the sixth and eighth days of life. This is a serious problem confronting the pediatrician because the newborn infant is extraordinary in its limited ability to clear bilirubin from the plasma. In addition, with rare exceptions, the newborn state is the only time when an elevated plasma bilirubin concentration, *as such*, poses a potential threat of brain damage.

The blood-group incompatibilities include, particularly, the Rh and the ABO systems. Here, the jaundice may be severe and can appear very soon after birth. In serious cases, if untreated, it can end up fatally or with a severely damaged brain. The condition is caused by a blood-group called the Rh (for rhesus monkey) factor. If a child is born of an Rh-positive father and is Rh-positive, and if the mother is Rh-negative, there is incompatibility between the two groups. The mother has produced antibodies against the Rh-positive red blood cells of the foetus. (In the first-born, the risk may not be great, but in subsequent pregnancies, the risk progressively increases.) This antibody produces lysis (breakdown) of the newborn's red blood cells with progressively increasing jaundice. This incompatibility can be tackled, provided the condition is detected early and an exchange transfusion, with compatible Rh-negative blood, is given in order to reduce the bilirubin levels in the blood. The situation is very similar in the case of the ABO incompatibility.

In the case of glucose-6-phosphate dehydrogenase deficiency, the red blood cells, which are normally subjected to numerous chemical insults in the body, get damaged at the cell membrane level. The repair of this damage is somehow related to glucose metabolism; the exact mechanism is not fully understood. What is known is that deficiency of the above enzyme leads to improper repair of the damaged cell membrane, leading to lysis of the red blood cells and jaundice. The other rarer forms mentioned are based on inherited metabolic defects of liver cells.

persistent carriers has been estimated at 120 million! The prevalence of hepatitis B surface antigen in *apparently healthy* adults varies from 0·1 per cent in parts of Europe, North America and Australia, to 15 per cent in several tropical countries. In India, the figure varies from place to place and a range of five to 50 per cent has been reported. A recently published study conducted at the Haffkine Institute in Bombay utilising the most sensitive detection technique reported a percentage of five in apparently healthy voluntary blood donors.

In low prevalence countries, a major mode of spread is the inoculation of blood and some blood products. The virus is transmissible via blood transfusion, or accidental inoculation of very small volumes of blood as seen in the surgery or in dental clinics. It is also a cause of concern in the case of addicts who take injected drugs. In most cases, the needles are not sterilised; this can also happen in tattooing as well as in piercing of the nose and the earlobes for wearing of jewellery. It has also occurred in situations like mass immunisation, laboratory accidents and acupuncture. Accidental inoculation of the virus in the home, or in dormitories through the communal use of razors, tooth brushes, bath brushes, etc, has also been reported.

In determining the prevalence of hepatitis B virus, an important factor is the transmission from carrier mothers to their newly born infants. The risk of such infection in some countries has been estimated to be as high as 40 per cent. Acute hepatitis B can occur occasionally in pregnancy, when it is often fatal. If it occurs in the second or third trimester, or within two months after delivery, there is a distinct risk that the baby will be infected. This is another subtle method adopted by the hepatitis B virus to ensure its own survival.

Other modes of transmission of hepatitis B may include mouth-to-mouth transmission. Hepatitis B surface antigen has been detected in the saliva of patients with acute hepatitis B as well as in carriers. The disease can also be transmitted sexually. Sexually promiscuous persons have shown a higher than expected incidence of antibody-positive sera. As the hepatitis B surface antigen has been found in the semen, vaginal fluids and menstrual blood, it is possible that it may cross mucosal surfaces exposed to these fluids during intercourse. This might, perhaps, explain the alarming increase of hepatitis B, particularly in the economically developed countries. Interestingly, human transmission studies conducted many years ago — where faecal extracts from hepatitis B patients were given to volunteers orally or by injection — failed to demonstrate the infectivity of faeces and no hepatitis B epidemics due to contaminated food or water have been observed.

Studies in several areas, especially of Asia and Africa, have shown that patients with primary hepatocellular carcinoma show an excess prevalence of HBsAg and anti-HBs, indicators of active HBV infection, as compared with matched controls, or with the general population. This is an interesting finding even though a cause and effect relationship has by no means been established.

Treatment, prevention and control

There are as yet no drugs available in the market that can act specifically against the hepatitis viruses. The usual treatment for viral hepatitis consists of alleviation of the symptoms and the adoption of supportive measures such as administration of vitamins. In *all* cases, consumption of alcohol must be totally prohibited. The patient should preferably be confined to an infectious diseases hospital. The patient must get adequate rest. A high-caloric, low-fat diet is prescribed. Often corticosteroids are administered. However, it must be noted that the role of these drugs in viral hepatitis is, at present, controversial.

Active research is in progress, around the world, directed towards the ultimate goal of finding drugs that can act specifically against the hepatitis viruses. A notable candidate amongst such antiviral agents might be interferon in the case of hepatitis B. Interferon is a natural low molecular-weight protein which is produced by almost all virus-infected cells; when introduced into non-infected cells, it somehow renders them resistant to replication of viruses and thus protects them from the destructive action of such viruses. Interferon derived from cell cultures of human leucocytes was given to patients suffering from chronic hepatitis B virus infection. There was an apparent inhibitory action on some of the hepatitis B virus components, during the treatment. While these preliminary findings are encouraging, as it stands today, interferon is still undergoing trial and is not available in routine clinical practice.

Short of developing specific vaccines (see box, p. 24), the only effective means of control in hepatities A lies in enforcing proper sanitation and hygiene. The virus is particularly resistant to standard methods of water

How research progressed

Hepatitis A was previously called *infectious hepatitis*, and hepatitis B, *serum hepatitis*. These terms were used because it was believed that hepatitis A was transmitted *exclusively* by the faeco-oral route, from person to person, and hepatitis B exclusively by the parenteral (injected) route. Since, however, it was subsequently shown that both viruses could be transmitted by routes other than those exclusively ascribed to them, the non-committal terms, hepatitis A and B, are now used.

While it is true that recorded history is older in the case of hepatitis A, in our opinion, the evolution of virus B need not have been after that of A, since the ancients might well have got infected with virus B, even without possessing syringes and needles. For example, they could have passed the virus from person to person by the mouth-to-mouth or other routes, which today are believed to maintain virus B in nature. The earliest reference to what was probably hepatitis A in western Europe was in a letter written in AD 751 by Pope Zacharias to St. Boniface, Archbishop of Mainz. Subsequently, there were several epidemics, especially during wars, from the Franco-Prussian to the Viet Nam. Between wars, hepatitis A revealed its presence through sporadic cases and minor epidemics. Excellent research on this disease was carried out in England, Germany and the USA between 1908 and 1962, which paved the way towards a breakthrough when Feinstone and others, in 1973, first showed the presence of the virus in the faeces of a patient, using immune electron microscopy.

In hepatitis B research, a masterly piece of epidemiological detective work in 1883 by Dr. Luerman of Bremen revealed the mode of transmission of jaundice, probably caused by hepatitis B virus, although, of course, he did not have the equipment to visualise the virus at the time. There was an outbreak of smallpox amongst the workers at a shipbuilding yard. Vaccination was carried out and the batch of vaccine used contained human immunising material instead of the usual Jennerian calf-lymph vaccine. After a long incubation period, there were cases of jaundice. By excluding water- and food-borne diseases, Dr. Luerman concluded that the outbreak must have been produced by an unknown infectious agent.

Again, further spadework was carried out in Germany, the UK and the USA and a new era in hepatitis B research began, when Dr. Blumberg, in 1964, discovered the Australia antigen, which we today designate as hepatitis B surface antigen (HBs Ag). This discovery was the focal point of several pioneering studies on the fundamental virology of hepatitis B virus, which culminated in the production of a homologous vaccine for use in man. For his original work Blumberg was awarded the Nobel Prize in 1976 (see SCIENCE TODAY, December 1976).

The hope for vaccines

The ultimate answer in the prevention of hepatitis lies in the development of safe, effective and economically available vaccines, specific against each virus, since there is no cross-immunity between the two. Such an ideal can be realised only when both HAV and HBV can be grown in suitable cell culture systems. Nevertheless, there have been some encouraging developments in the hepatitis B vaccine field.

One concerns a subunit vaccine prepared from the small spherical particles of HBsAg. To safeguard against any residual, live HBV remaining in the preparations, they were inactivated by formaldehyde. The vaccine was reported to be safe, immunogenic and effective in preventing hepatitis B in chimpanzees, regarded as the only suitable non-human primates which can be infected with HBV. Initial small-scale safety tests of such vaccines are now in progress in volunteers.

The other interesting development concerns another experimental hepatitis B vaccine based on the small spherical particles of HBsAg. These were partially purified on solid immunoadsorbent columns containing anti-HBs of human origin and antibodies of animal origin to human serum. After safety tests in chimpanzees, it was administered to the patients and staff of a haemodialysis unit. The incidences of HBV infection between the immunised group and a group of patients and staff not receiving the vaccine showed a marked difference, even though better controls might have been included in the study.

The above-mentioned experimental vaccines are inactivated products and, as such, exhibit the usual advantages (safety) and disadvantages (comparatively short-lived immunity) of "killed" vaccines. In addition, as Dr. Zuckerman has pointed out, the above-mentioned vaccines have one unconventional aspect: they utilise viral material obtained from an *in vivo* human source, such as, serum. It is well-known that during the replication of HBV in liver cells, in addition to virus-coded antigens present in HBsAg, proteins from the human host cells are also incorporated into the 22 nm HBsAg particles from which these particular vaccines are prepared. This raises the possibility of the production, when inoculated into the person being immunised, of serious autoimmune diseases, not excluding the chronic forms of hepatitis.

It is interesting to note, in this context, that such vaccines are unconventional, in the sense that, to the best of our knowledge, *they represent the first homologous immunogenic materials from an* in vivo *source, being obtained from man and destined for ultimate use in man.* Hence, scientists ought to be cautious in the long-term evaluation of such products and to explore other avenues of research which might circumvent such problems. Indeed, efforts have been under way in certain laboratories in the USA and the UK to develop a vaccine based on immunogenic small polypeptides obtained from HBsAg, rather than utilising the HBsAg particles themselves. Indeed, the possibility is also being considered of synthesising such small polypeptides *de novo,* so that, hopefully the possibility of production of autoimmune disease can be ruled out. However, one can visualise the limitations imposed on such vaccines from the points of view of production costs and technical logistics.

One approach which, perhaps, has not yet received adequate attention abroad but has been receiving our attention at the Haffkine Institute in the recent past, is the possibility of development of a "live", attenuated anti-HBV vaccine, in an animal species heterologous to man. Work is going on at the Institute towards development of systems of replication of HBV in common laboratory animals. The advantages of live vaccines are too well-known to merit detailed discussion here; we know the most important advantage is of long-lasting immunity. Their disadvantages, however, such as the possible danger of reversion to the wild types of virus and the possibility of side-reactions, such as allergy resulting from the use of contaminating heterologous antigens, cannot be ignored. What's more, in the case of HBV, one must seriously consider the possible oncogenic potential of this virus, in view of what has been noted earlier about the reported positive correlation between the prevalence of the chronic HBsAg carrier state and occurrence of hepatocellular carcinoma.

In conclusion, we can only state a scientifc truism improvised by us: "The only good vaccine is a dead vaccine — until a safe and effective live one can be developed !"

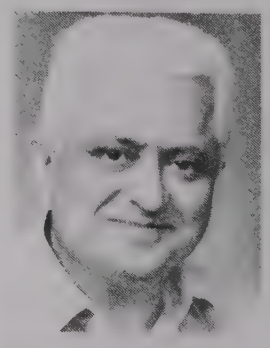
sterilisation, including chlorination at the usual levels of concentration. Hence, boiling for 10 minutes is the safeguard for potable water. However, ultimate control lies in achieving optimal levels of general community hygiene and safe disposal of faeces. Besides the faeces, the blood and, possibly, the urine of patients must be considered infectious and adequate measures must be taken for their disposal. In the laboratory, every precaution must be taken to ensure that the staff do not get infected. The method of choice of sterilisation of equipment is autoclaving (steam pressure); glassware can be sterilised with dry heat (at 180°C for one hour).

The efficacy of giving pooled, normal human immunoglobulin in the attenuation or prevention of clinical hepatitis A has been established. However, it should be within the limits of availability of supplies and be directed mainly towards high-risk individuals.

In the case of hepatitis B, infection can be minimised by avoiding the use of blood and certain blood products, unless absolutely necessary, and making certain that all syringes and needles and surgical and dental instruments are properly sterilised. Autoclaving is the method of choice. Also, routine screening of all blood donors at blood banks for hepatitis B surface antigen, at least by a low-sensitivity method such as CIEP (but, preferably, more sensitive methods such as RPH and RIA) should be made obligatory.

Although human hepatitis B immunoglobulin has already come on the market abroad, due to its high cost and limited availability, it would be neither realistic nor justifiable to utilise this preparation with every transfusion. It should be reserved only for high-risk cases and patients who are likely to receive multiple transfusions or who undergo major cardiovascular surgery, or repeated haemodialysis, and also surgeons and research workers who may have accidentally infected themselves.

In conclusion, it may confidently be stated that viral hepatitis A and B are infections, ubiquitous in their distribution, in which nothing could be more true than the old adage that an ounce of prevention is better than a pound of cure.



Dr. M. V. N. Shirodkar (49), Head of the Department of Virology at the Haffkine Institute, Bombay, studied at the Johns Hopkins University, Baltimore, USA, and later at the Yale University School of Medicine. In 1963, he received his ScD from Johns Hopkins University for his work on the tumour-producing Rous sarcoma virus. Besides his current research work on hepatitis and Rous sarcoma, Dr. Shirodkar teaches microbiology and applied biology at the Bombay University.

Dr. N. G. Chanderkar (36) is Senior Scientific Officer-in-Charge of the Radiation Biology Unit at the Haffkine Institute. His main fields of interest are nuclear medicine, immunology, haematology and epidemiology.

[The authors wish to thank Drs. K. P. Deodhar, R. S. Kamat and Beatriz Braganca for the photomicrographs.]

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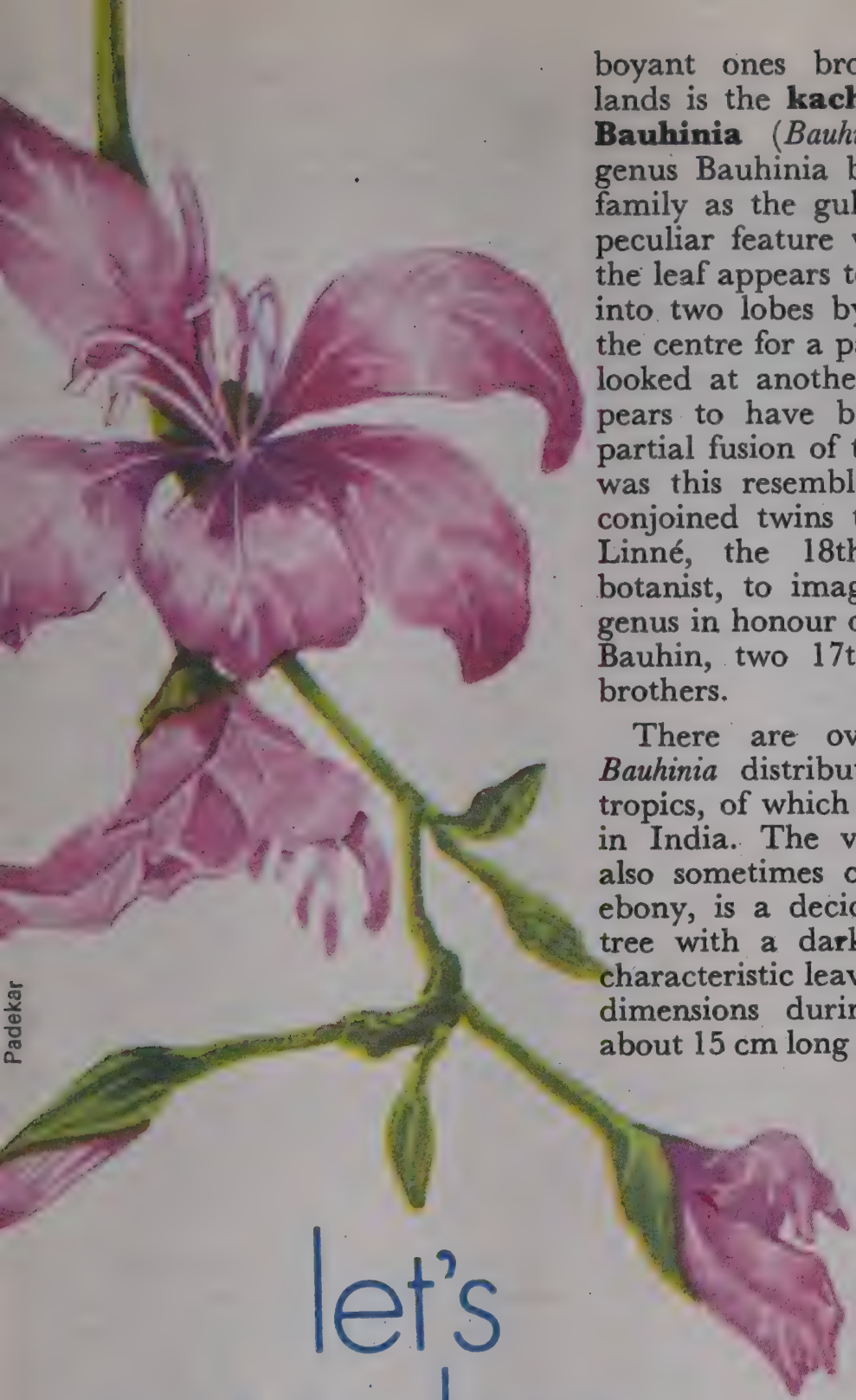


Padekar

Variegated Bauhinia

let's get to know our trees!

5 SOME MORE VILLAGE TREES

While the relentless monsoon winds lash the Indian landmass from the south-west, and rain-bearing clouds hasten to discharge their burden to sprout new life in every glade in the countryside, the memory of the brilliant floral displays of spring and summer fade out to make way for the verdant splendour of trees in dark emerald attire. This is the time for vigorous growth and multiplication of the species. Some trees like the *kachnar* and *ber* have cast their seeds around to be nurtured and strike root in the damp soil; others like the *kadamba* and *babool* are on the verge of bursting into bloom.

An indigenous tree which can hold its own in beauty amidst the flamboyant ones brought from foreign lands is the **kachnar** or **variegated Bauhinia** (*Bauhinia variegata*). The genus Bauhinia belongs to the same family as the gul mohr but has one peculiar feature which sets it apart: the leaf appears to have been divided into two lobes by a slit going down the centre for a part of the length, or, looked at another way, the leaf appears to have been formed by the partial fusion of two oblong lobes. It was this resemblance of the leaf to conjoined twins that prompted Carl Linné, the 18th century Swedish botanist, to imaginatively name the genus in honour of Jean and Gaspard Bauhin, two 17th century herbalist brothers.

There are over 250 species of *Bauhinia* distributed throughout the tropics, of which about 40 are found in India. The variegated Bauhinia, also sometimes called the mountain ebony, is a deciduous medium-sized tree with a dark brown bark. The characteristic leaves attain fairly large dimensions during the monsoon — about 15 cm long and almost as broad. During this time a few ripe pods (15 to 30 cm long and containing 10 to 15 small, flat, roundish seeds) may still be found hanging from some branches, though most have already disseminated their seeds in the earlier months; newly germinated seedlings, too, may be found around the base of the tree.

Kachnar flowers are quite large and bloom on the bare branches when the tree is almost leafless during the summer. The calyx of each flower is tubular with a spathe-like limb as long as the calyx from which it has arisen. Five distinct petals spread out and curve slightly into broad claws. Two varieties of kachnar are recognised on the basis of petal coloration: one with purple flowers of which four petals are a light purple and the fifth large and coloured deep purple, and the other with white flowers in which the fifth petal is variegated with yellowish-green or dark purple. The flowers, disposed on short racemes, or in the angles of the leaf stalk, are fragrant and attract bees which thus act as pollinators; often sunbirds may be seen to probe the flowers for nectar.

The kachnar is found wild in many parts of India — from the western Himalayan foothills eastwards up to Assam and in western and central India; yet, in many parts of the country, the tree is largely grown as an ornamental tree. Its bark yields a tannin and also a gum; a rough fibre obtained from the bark provides a coarse cordage. In indigenous medicine, bark extracts are used in skin diseases and ulcers. Its seed extract is said to possess the property of agglutinating the blood cells. Bauhinia leaves make a rich and nutritious fodder for livestock. Villagers in the Ghat areas of Maharashtra make forays into the forest during the rainy season in search of edible pot herbs, and the fresh buds and leaves of *Bauhinia* species, called *kavlya-chi-bhaji*, are made into soups and curries. A Gond song describes how one may plant ten kachnar trees and care for them and yet they would not grow as well as those in the forest! The white-flowered kachnar is associated with Lakshmi, the goddess of wealth. Kalidasa's *kanchan* is believed to refer to *Bauhinia acuminata*, a small tree (or shrub) with large, pure white flowers which bloom all the year round. In Maharashtra, the leaves of *Bauhinia racemosa* are exchanged on the

Purple Bauhinia (*Bauhinia purpuria*)

Padekar

Bauhinia leaf

Dassera day as tokens of gold and goodwill.

Interestingly, not all *Bauhinias* are trees; an exceptionally interesting species is the **chambelli** (*Bauhinia vahlii*) — a gigantic woody climber which may grow beyond 40 metres in length, and up to half a metre in diametre. This rather unusual plant is sometimes encountered in mixed deciduous forests, but while the casual visitor may be impressed by its very large leaves, creamy white flowers or the 30-cm-long fur-covered pods, the forest personnel look upon it as a destroyer of many fine timber-yielding trees.

The big pods of this climber burst with a loud report during the summer and hurl their large, flat seeds some distance away; the pod then becomes spirally twisted and dries up (see photograph on p. 29). Chambelli leaves serve as plates and are also used for making rustic umbrellas; its seeds are eaten roasted (the seeds are believed to possess both tonic and aphrodisiac properties!).

The **kadamba** or **neepa,** both Sanskrit names for *Anthacephalus kadamba*, has had a long association with Indian life and culture. Of the three Indo-Malayan species of the genus *Anthacephalus*, the *kadamba* is indigenous to our country. It is a medium-sized deciduous tree which can reach to a height of about 10 metres or so, the trunk growing straight up and supporting a dense, round crown of fine foliage. In India the tree is widely distributed — from the sub-Himalayan tracts extending eastwards to Assam and southwards down the Western Ghats to Karnataka and Kerala (and even Sri Lanka). In its natural habitat, it grows well in moist conditions on well-drained alluvial soil. The kadamba's rapid rate of growth during the first six to eight years, attaining almost maximum size in about 20 years, and its close foliage, make it a good shady and ornamental roadside tree.

The leaves of the kadamba are oblong-elliptic, between 12 and 24 cm long, fairly broad and end in a short, blunt point; the upper surface of the dark green leaves has a sheen and one can discern a fine woolly covering on the lower surface. The orange-coloured flowers which appear in large numbers from May to September are small and tubular and are arranged on a fleshy, globular head giving the cluster the semblance of a fluffy, hairy ball about 5 cm in diametre; these flower-heads are solitary, highly fragrant and hang from peduncles (stalks). The globular fruits are actually composed of individual pyrenes (capsules) aggregated together in each fleshy head (such fruits are known as syncarpiums).

The fragrant flowers of the kadamba attract a variety of small insects and bees; the fruits are edible, both for humans and cattle (and bats, too). In fact, the natural regeneration of this tree depends rather upon cattle excreta which contain many undigested small seeds. The fluffy flower-heads are often collected by village children for play.

Kadamba wood is soft and easy to work with, moderately strong and is used for making cheap boards, packing cases, tea chests, etc; in some regions, dugout canoes are hewn out of trunks of the tree. The wood pulp is used for paper-making.

Since ancient times, kadamba flowers have been used for offerings in temples around which the trees were often planted. Buddhist monks, too, have been known to grow these trees. In ancient lores, it is reverentially associated with Lord Krishna and his beloved Radha who used to meet him as he played his flute under the tree. It is even believed that Krishna climbed a kadamba tree to dive into the river Jamuna in order to subdue the serpent Kaliya. In his monumental work *Meghadootam*, Kalidasa wrote how women decorated their hairdo's with kadamba blossoms during the rainy season. Also a "woman and tree" design in sculpture (found near Mathura) belonging to the Kushan period depicts a woman with a sword in one hand and touching the ball-like flowers of the kadamba with the other. The release last month by our Post and Telegraph Department of a stamp depicting the *kadamba* in bloom (below, left) is indeed a fitting tribute to a tree of such great antiquity and significance.

The **baheda** is a tall and handsome tree of our countryside with its spreading canopy, light grey-brown bark and leaves clustered at the ends of the branches. The botanical generic name, *Terminalia*, is derived from this characteristic terminal clustering of the leaves; the specific name, *bellerica*, is the Latinised form of its Arabic name. Of the 16 *Terminalia* species India has, the most important ones commonly encountered are (besides baheda): the **harda** (*T. chebula*), the **desi badam** (*T. catappa*), the **asan** or **ain** (*T. tomentosa*), and the **arjuna** (*T. arjuna*). All are indigenous trees; some have even been mentioned by Valmiki in the *Ramayana*.

The baheda, known in Sanskrit as *vibhitaka*, is a deciduous tree largely distributed throughout peninsular India, but rarely seen at altitudes above 1,200 metres, and is not found in the arid zones. The tree reaches a height of about 40 metres with a girth of two to three metres. The lower portion of the straight trunk is often buttressed to give it strength and rigidity. Its leaves, which are shed during the summer, appear shortly before the monsoon and are a dull brick-red in colour at first and mature into thick, dark green; broadly elliptical, the leaves are about the size of an outstretched hand.

Between March and June (and sometimes later), the tree comes into bloom; these are small, creamy-white flowers, cup-like in appearance with ten stamens poking out from them. The numerous scented flowers are borne on thin stems and a number of these spikes are borne in the axils of the terminal clusters of leaves. (Actually, it is rather difficult to spot the small flower clusters from the ground level as these grow high up in the canopy.)

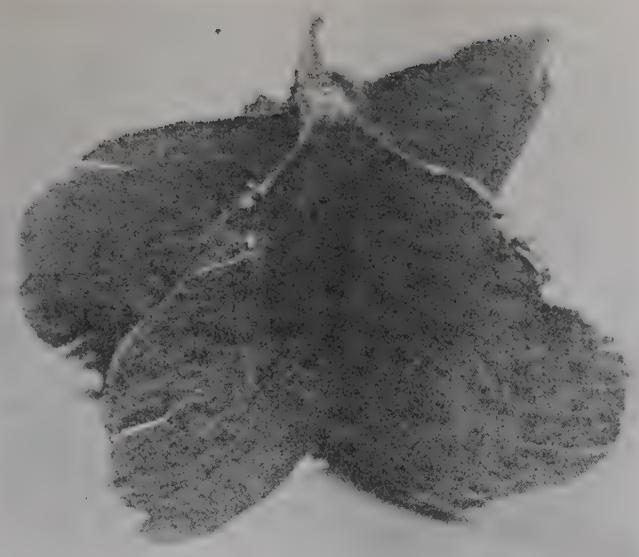
The roundish fruits, on the other hand, are conspicuous because of their brown colour and large numbers. Each fruit is about two to three cm in diameter and is covered with a coat of fine, brown, velvety fur. When the tough pulp is removed along with the

fruit skin, a hard stone enclosing the seed is seen. Many herbivorous animals eat the outer portion of the fruit, and on many occasions one may find the hard stones nibbled away with the seed inside missing — this is the handiwork of squirrels. Sometimes piles of these stones, systematically smashed open, can be found under the tree, a sure sign that village folk have been collecting the edible seeds. The seeds have a nutty flavour, but eaten in large numbers, they produce a narcotic effect. Some villagers eat the seed kernel with betel leaf and betel nut as a treatment for indigestion. The seeds yield an oil which has been used as a hair oil, and for soap-making; it also has a purgative action like that of castor oil. The oil is also employed as an external application for rheumatic pains.

Baheda leaves are eaten by livestock and are also fed to the tussar silk-worm (*Antheraea mylitta*). Though baheda wood is hard and strong, it tends to crack during working and it does not take a polish; however, being durable under water, it is used in the construction of boats and planking. By far the most important part of the tree is its crop of fruits, known commercially as Belleric myrobalan, which contain about 20 per cent tannin and are, therefore, used for tanning leather and ink-making.

A still more economically important myrobalan tree is the chebulic myrobalan (*T. chebula*). A medium-sized deciduous tree, this myrobalan, known as **harda** (*haritaki* in Sanskrit), is found in the deciduous forests practically all over India. Its leaves have a rounded base unlike the tapering bahedas. The flowering is similar to the belleric myrobalan's and the fruits ripen from November to March. The fruits are ellipsoid rather than globular and are ribbed from end to end longitudinally. These are collected from January to April, dried, classified and sorted according to quality and sold commercially, especially for tanning and medicinal use. The tannin content of the fruit exceeds 30 per cent (the tannin is of the pyrogallol type with a high ellagitannin content; this makes it very useful for tanning of sole leather). The tannins of harda are in great demand and large quantities are exported. For instance, harda tannins have been used in ink-making, for internal treatment of locomotive feed waters, as an additive in oil drilling compositions, as an anti-corrosion agent, in petroleum purification, etc.

Harda fruits have for long been used as a laxative and tonic; it is one of the three components of the Ayurvedic preparation, *triphala churna*, the other two being the amla (*Emblica officinalis*) and baheda (*T. bellerica*). The laxative effect is attributable to a glycoside in the fruit pulp resembling Sennoside-A, the active principle of senna pods (*Cassia angustifolia*). An anti-spasmodic substance, called chebulin, has also been extracted. The fruit pulp is used by herbalists for application to bleeding gums and as a dentifrice. Harda wood is hard and is used for making posts, beams, tool handles, etc.



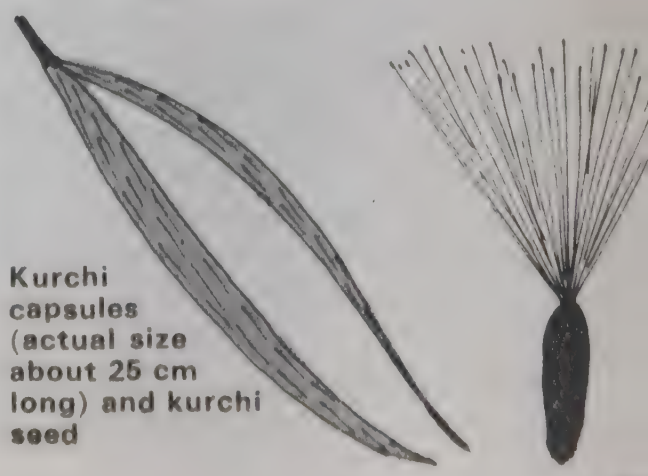
The winged fruit of ain

In the rainy season, the **desi badam** (*T. catappa*) goes into dense foliage and grows heavy with fruits which are ellipsoid and green, with a tinge of red. This deciduous tree is a native of the Andamans; it is now extensively grown in our gardens and estates as an ornamental tree. Its visual appeal lies in the symmetrical whorled disposition of its branches, and the large green leaves that turn dark red as they age and fall off.

The kernels of desi badam are edible and have an almond-like flavour. The leaves make a good fodder for livestock and feed for the tussar silk moth larvae. The hard shells covering the seeds have been shown by Indian chemists to be rich in pentosans and are, therefore, a good source of the chemical furfural. The bark contains a colouring matter that is used for dyeing silk and other natural fibres into various shades of grey, fawn and brown. In South India, herbalists are said to use the juice of young leaves as an application for scabies and skin conditions. The wood, too, is useful as a good constructional timber.

All the three *Terminalia* species we have described here have fleshy fruits, but this is not a common feature of the genus. Two species of *Terminalia* whose fruits are altogether different — they have five wings (these are thin, dry, expanded portions of the external covering) — are the **ain** and the **arjuna** trees. Both are Indian trees known since ancient times: Valmiki had referred to the former as *sarja* and to the latter as *arjuna*. These two trees are essentially forest trees. The arjuna is evergreen, has a white bark and usually grows along a river bank or a stream, whereas the ain is a deciduous tree, with dark blackish-brown, highly fissured bark growing amidst other trees on flat ground generally. Flowering and fruiting occur during summer, and when the rains come, their winged fruits are knocked down and tossed around by wind and rain; the fine symmetry of the fruits is lost as the wet wings are frayed by the elements, but the scattered fruits stand a good chance of germinating and taking root, more so because animals do not seem to find the fibrous winged fruits very attractive as food. Both trees yield excellent hard timber. Arjuna bark has been used in indigenous medicine and some investigators have reported diuretic and blood pressure relieving properties and a general tonic effect in cirrhosis of the liver.

Largescale felling of trees in forest areas leaves massive scars in the terrain that may require many years to be recolonised by new tree and shrub species. In such areas, and even in patches destroyed by forest fires, one small tree usually survives — this is the **kurchi** (*Holarrhena antidysenterica*). Famed for its medicinal properties since bygone ages (both Valmiki and Kalidasa mentioned this tree, the *kataja*, as it is known in Sanskrit), the kurchi is the first to colonise waste land and the last to vanish; even from burnt trunks new shoots emerge and live and grow. The *kurchi* grows throughout the Indian peninsula up to an altitude of 1,200 metres. A deciduous tree, its new leaves appear in April or May, but the first flush of the monsoon is enough to encourage a surge of growth and what was to all appearances an inconspicuous shrub becomes a lush bush with dark green entire leaves and with green flower buds. It generally flowers just before the rains but sometimes a second flowering takes place during September to November. The young plants grow gregariously and during the rains one may see numbers of them on the plains as far as the eyes can see. The Assam specimens are fairly large trees.



Kurchi capsules (actual size about 25 cm long) and kurchi seed

The leaves are 10 to 30 cm long and about 5 to 15 cm broad and ovate or elliptical. The flowers are bunched together and look like small white bouquets. The thin white petals spread out and separate from a tubular corolla. The fruits are a pair of long, slender, tapering capsules containing numerous small seeds with a tuft of silky hair at one pole; these hair help carry the seeds over long distances on the wind when the capsules burst (in the following summer).

The kurchi belongs to the dogbane family (*Apocynaceae*) and is, therefore, potentially poisonous, but it has some medicinal value as well. The aerial parts of the tree contain alkaloids, the principal one being conessine (0·2 to 4 per cent); the maximum concentration occurs soon after the rainy season. This alkaloid is an effective agent in treating amoebiasis, but it produces some nervous symptoms like tremors and restlessness, giddiness and also intestinal disturbances. The kurchi is officially recognised by the Indian Pharmacopoeia which lists two of its preparations: liquid extract of kurchi, and kurchi bismuth iodide. The preparations are made from the bark (commercially known as conessi bark) and contain 2 per cent of the total alkaloids.

The flowers are eaten cooked and the leaves are used as livestock fodder. The finer specimens from Assam yield a soft, light-coloured wood used for carving, making boxes, toys, combs, etc and also light furniture.

A fairly large tree which does not look very conspicuous in a mixed forest is the **kumbha** (*Careya arborea*). This deciduous tree becomes noticeable only in March or April when a rather unpleasant sweetish smell pervades the summer air; if one looks around, one can spot the kumbha bereft of leaves, sporting a few clusters here and there of those malodorous creamy flowers. The large flowers look like brushes with their numerous stamens displayed prominently; each flower has four petals and four sepals of the thick calyx. Come the rains, and new leaves grow to attain a large size. These leaves are like those of the Indian almond. In July and August, the tree bears fruits, about 10 cm in diameter, which are pitcher-shaped (hence the Hindi name *kumbha*).

Kumbha flowers (left) and below it the kumbha fruit (photo by S. R. Nayak)

There are nine species of *Careya* in the Indo–Malayan region. The kumbha is found in most of India's forests up to 1,600 metres altitude. Kumbha fruits have a sweet, fibrous, edible pulp in which are embedded the peanut-sized seeds which are poisonous, presumably because of their high content of saponin, a highly irritant substance. Yet the tree has medicinal value; the bark is a demulcent in coughs and colds, and also an antipyretic agent (reduces fever). The fleshy calyces contain plenty of mucilage and is used to treat coughs and cold; it is dried and sold under the name of 'vakumbha'. The tannin-containing leaves are used as wrappings of *bidis* and cheroots. The inner bark rubbed on footwear is said to keep away leeches.

Kumbha wood is heavy and durable, especially under water; it is difficult to saw but gives smooth shining finish and takes a good polish. It is used for agricultural implements, cabinets, gun-stocks, sleepers, etc after treatment. The bark is fibrous and gives a coarse cordage; it is also used to make brown paper.

Most of us at some time or other must have tasted the plum-like fruit of the **Indian jujube** or **ber.** The ber tree has a long history in India and the earliest records can be traced to the Chalcolithic Age (1500 to 1000 BC). The ber fruit has been mentioned

Padekar

Kurchi flowers and leaves

in our ancient texts like the *Yajurveda*, the *Brahmanas*, medical texts and the works of Kautilya, Panini and Patanjali.

In recent years, the confusion that existed regarding the exact botanical identity of Indian jujubes appears to have been resolved. The consensus is that the true Indian jujube (ber) is *Ziziphus mauritiana* and that the introduced Chinese jujube is *Ziziphus jujuba* under which name every kind of ber used to be lumped together.

Our ancients had their own method of identifying ber types and three of them were recognised: (i) *badara* with large-sized fruits (*badari* of Valmiki); (ii) *kuvala* with average-sized fruits; and (iii) *karkandhu* with small, orange-red or brown fruits. Botanists believe that the first two refer to varieties of *Z. mauritiana* and the third to the *Z. nummularia* (*chanibor* of Maharashtra).

The ber tree itself is moderately sized and in the wild state reaches up to a height of 12 metres. The leaves are single and three-nerved with either one or two prickles at the base of each leaf-stalk. There is some variation in the leaf sizes and especially fruit sizes because of the existence of polyploidy (multiple chromosomes) in the cultivated varieties. The wild type is not popular because of the small amount of pulp as compared to that of the cultivars. To encourage vigorous growth and good fruit crops, budding or grafting to root stocks is done.

The wild ber thrives well in the drier regions and may be found up to an elevation of 1,600 metres. It prefers an open terrain for its growth (a light demander) and the seeds disseminated by various natural means germinate very well — to such an extent that it may even be looked upon as a pest.

The flowering season of ber varies somewhat with the region in which it grows, but generally the season is November to January or April to October, and the fleshy fruits with a hard stone in the centre are obtained from October to March. The flowers grow in profusion from axillary cymes. Each small, greenish-yellow flower resembles a five-pointed star because of the disposition of the triangular petals.

Some horticultural varieties of the ber are known, for example, *uniran, sanaur; kaithili* and *dandan;* the differences between these are recognised in the amount of the pulp, the size and shape of the fruits and the stones, etc. The fruit, which can be eaten as such when ripe, is sometimes made into candies. The Burmese prepare a delicious syrup, with small-sized sour-and-sweet ber boiled with molasses or jaggery; this is called "*zee-yo*". Ber fruits are rich in sugars, vitamin C and minerals.

Medicinally, the ber fruit is regarded as cooling and tonic; it is one of the ingredients of the indigenous medicine, *Joshanda*, used for chest complaints. The kernels are said to be sedative and soporific, and are also made into poultices for wounds. *Badara* is believed to be an oral contraceptive.

(Left) Myrobalan

(Right) Climbing Bauhinia (chambelli) showing a burst pod with a spiral twist (photo by S. R. Amladi)

Ber timber is excellent wood for hard and durable items like axe handles, gunstocks, yokes, turnery and wheel parts. Ber leaves provide good fodder; the ber tree is a good host of the lac insect.

The ber has a special religious significance for the Sikhs — the "sorrow-removing tree" at the Golden Temple in Amritsar is a ber tree.

In this and the previous issue, we have talked about some of the important trees that one may come across in the countryside, around villages and on the forest fringes. Yet, we have hardly covered even a fraction of the rich variety that can still be seen. True, the richness of our ancient *vanas* (forest groves) and sylvan glades are now just a memory in lores, yet the sight of countless plants asserting themselves in their green garb is in itself a reassuring experience.

S. R. AMLADI

NEUROPHYSIOLOGY

Role of Endorphins

The discovery of the chemical 'enkephalin' capable of imitating the actions of natural opiates, such as morphine, in the brain has given a new dimension to studies on the physiology of pain and mood (see SCIENCE TODAY, March 1976, p. 26). What is noteworthy is that, subsequent to this, a large number of pain-killing chemicals, all peptides related to enkephalin but differing widely in pharmacological properties, were discovered. Known as the 'endorphin' family, these are now under detailed study. A significant discovery about endorphins, both from theoretical and from the practical points of view, has now been made by J. A. H. Lord, A. A. Waterfield, J. Hughes and H. W. Ksoterlitz of the Unit for Research on Addictive Drugs, University of Aberdeen, Marischal College, Aberdeen, UK. They have shown that not only are there several opioid peptides in the brain with different characteristics, but they act through several different types of receptor on the surface of the cells they activate. The details are reported in *Nature* (**267,** 495, 9 June 1977).

They conducted two sets of experiments. In the first, they tested the ability of peptides to depress the electrically-induced contraction of two kinds of voluntary muscle — guinea pig ileum and mouse vas deferens. In the second, they tested their ability to inhibit binding of tritium-labelled naloxone and leu-enkephalin in the homogenates of guinea pig brain.

If the receptors were the same for all the tissues and all the different peptides, then the endorphin that is the most potent in one test would also be the most potent in the others. In fact, from the differences in potency of the peptides they observed in different tests, they concluded that there may be about four different types of receptors.

They state that the present evidence is not sufficient to allocate different receptors to different physiological functions. However, their results do indicate that the system of opioid peptides, similar to the catecholamine system, is of considerable complexity in that several peptides are matched by multiple receptors. The results also suggest chemical differences between the members of the endorphin family. The large ones (α and β endorphins) are found in the intermediate and anterior lobes of the pituitary gland in high concentrations and they are not easily destroyed by enzyme action. The smaller ones (met- and leu-enkephalin) are present in lower concentrations in widely spread areas of the central and autonomic nervous systems and are destroyed very rapidly indeed by enzymes. It is possible that the big " parent " endorphins may be hormones with relatively long-term effects; for instance, they may be involved in dimming pain perception in special situations such as the battlefield and childbirth. The little ones may play the role of fast-acting neuromodulators or neurotransmitters in the moment-to-moment exchange of information between brain cells.

ASTROPHYSICS

Black Hole in Milky Way

What lies at the centre of our Galaxy — a pulsar, a quasar or a black hole? It is not possible for us to see the centre since clouds of gas and dust lie in between. However, from infra-red and radio observations we know that dense compact objects do exist in the centres of other galaxies. Strong evidence that the heart of our Galaxy may contain a massive black hole has now been provided by a team of radio astronomers from the US National Radio Astronomy Observatory (NRAO) in a recent issue of the *Astrophysical Journal Letters* (**214,** 61, 1 June 1977).

Prof. K. I. Kellermann and his colleagues D. B. Schaffer, B. G. Clark and B. J. Geldzahler had used long-base line interferometry, a standard and well-established technique for locating small radio sources to observe the compact radio source Sagittarius A West at the centre of the Milky Way at a wavelength of 4 cm. By hooking up the existing radio telescopes from the west to the east coast of the United States (Tyngsboro in Massachusetts, Green Bank in West Virginia and Goldstone in California) they achieved a baseline of 105 million wavelengths for a radio interferometer.

Their results, combined with those from shorter baselines, indicate that the radio emissions from the centre are concentrated in a region of size in the range 0·01 to 0·02 arc seconds, confirming the observations made two years ago (see SCIENCE TODAY, March 1976, p. 25). The new evidence is that they have discovered a region less than one-thousandth of a second across, emitting 25 per cent of the central power. Translated into linear measure, this represents a size 10 times the Earth-Sun distance.

The radioluminosity of the centre of the Galaxy was found well below that of the quasars. But the volume emissivity was much greater as compared to quasars. The observed brightness temperature of five million degrees ruled out a thermal origin for the radiation. The emission is probably generated by relativistic particles and magnetic fields. The radio size, in fact, corresponds to a black hole of 100 million solar masses; this is close to the upper limit for a condensed object at the centre of our Galaxy. The authors say: " The detection of a radio source with milli-arc second dimensions has been suggested as a possible test of the presence of a black hole." The observations do not prove that such a black hole exists, but neither do they go against the suggestion.

BOTANY

Flavonoids in Fossil Leaves

The chemical evolution of flowering plants has been studied by Karl J. Niklas and David E. Giannasi of the New York Botanical Garden, Bronx, New York, USA, from an analysis of the organic chemistry of a dozen still-green fossil leaves of the tree *Zelkova oregoniana*, a member of the elm family. The trees were buried under volcanic ash at Succor Creek in Oregon some 30 million years ago.

The New York biochemists particularly studied the plant pigments, flavonoids. The most complex flavonoids are found only in the evolutionarily advanced flowering plants, while the lower ferns and mosses have only simple types and algae have no flavonoids at all. These chemicals perform numerous functions in plants such as attracting bright coloured insects, regulating growth, capturing light and protecting the plant with bitter tastes. *(Contd. on p. 55)*

the four colour conjecture

a post-mortem

N. M. SINGHI

The simplest way to show that four colours are necessary for flat maps is to draw four regions so that each one touches the other three, as in the map A drawn here. Each of the three outside regions requires its own colour, and the centre must have still another. In map B, three colours are sufficient for the four states Karnataka, Tamil Nadu, Kerala and Andhra Pradesh, but one more colour is needed to distinguish the outside seas. The fact that there are flat maps which require four colours was demonstrated about 123 years ago. Since then mathematicians had been attempting to draw a flat map which needs five or more colours. Recently Apple and Hakin have shown that this cannot be done

An eventful date for decades to come in mathematics would be 22 July 1976. For, the well-known four colour problem, which fascinated mathematicians, engineers, physicists and linguists alike — even laymen did not hesitate to try to produce a solution to it — was announced as solved on this date. A battle fought by many fertile and devoted minds for the past hundred years has thus, perhaps, come to an end. Professors Wolfgang Hakin and Kenneth Apple of the University of Illinois, USA, have finally proved that it is possible to colour any flat map by four colours, so that no two adjoining regions are coloured alike (Fig. 1). To understand the significance of their solution, it is necessary to go back to the 19th century.

The four colour problem, which came to be known in mathematical circles as the "four colour conjecture", was first posed about 123 years ago. Francis Guthrie, a post-graduate student at the University College, London, observed that four colours were enough to colour the counties on a map of England in a way that no contiguous counties were of the same colour. He wondered whether that was true for all maps ! A letter dated 23 October 1852 from

MAP B

Fig. 1 MAP A

Professor Augustus de Morgan to Sir W. R. Hamilton also mentions the problem. De Morgan acknowledges in the letter that the problem was first asked by one of his students, who was, perhaps, Guthrie.

The problem, however, did not create any stir in the mathematical world for another 30 years. It appeared in print, for the first time, in June 1878, in the form of a question posed by the well-known mathematician Cayley. Cayley again stated the problem in the first volume of the *Proceedings of the Royal Geographical Society* in 1879.

The first attempt to solve the problem was made by Kempe. He used an argument which may be considered as a modification of the one used to prove the "two colour theorem" (Fig. 2). He claimed that he had proved the four colour conjecture. Kempe's paper was published in 1879-1880.

About ten years later, after Kempe's death, P. J. Heawood published a paper in which he showed that there was a flaw in Kempe's proof. Heawood, however, pointed out that the proof could be modified to show that *five* colours were enough to colour any flat map in a way that no two regions with common boundaries had the same colour. Kempe, in fact, left this world without realising that a problem which he had the satisfaction of "solving", was to continue to defy one and all in the years to come. (P. G. Tait is another famous mathematician who had given an unsatisfactory "solution" to the problem in 1880.)

Mathematicians as a lot are very fond of generalising, particularly when they are unable to comprehend something. It gives them a deep satisfaction to pose a problem or prove a theorem in as much generality as possible. Heawood, hence, did not leave the matter where he picked it up. He first observed that given any flat map one could draw a new figure by joining the capitals of the adjoining regions. This new figure is called a *dual map* of the original (Fig. 3 is an example of a dual map). Graph theorists do not use the word "capitals". They call the points denoting capitals, 'vertices'. The advantage of a dual map is that you have only to colour the vertices in place of whole regions in the original map.

This is clear because vertices in the dual map are joined, if and only if, in the original map the corresponding regions have a common boundary. To distinguish this new type of colouring, we shall call it vertex-colouring. Thus, vertex-colouring of a map means you colour the vertices in such a way that any two vertices which are joined get different colours. The vertex-colouring is easier to visualise and graph theorists prefer to state their theorems in terms of the new type of colouring rather than the usual map colouring.

Fig. 3 'Dual map' of a given map is obtained by taking a point inside each region, say, the capital of the region or an important town, and joining the capitals of adjacent regions by curves, say a railway line. The diagram below (map D) is the dual map of the northern part of India (map C). This diagram also shows that a vertex-colouring of the dual map and a colouring of the original map correspond to each other

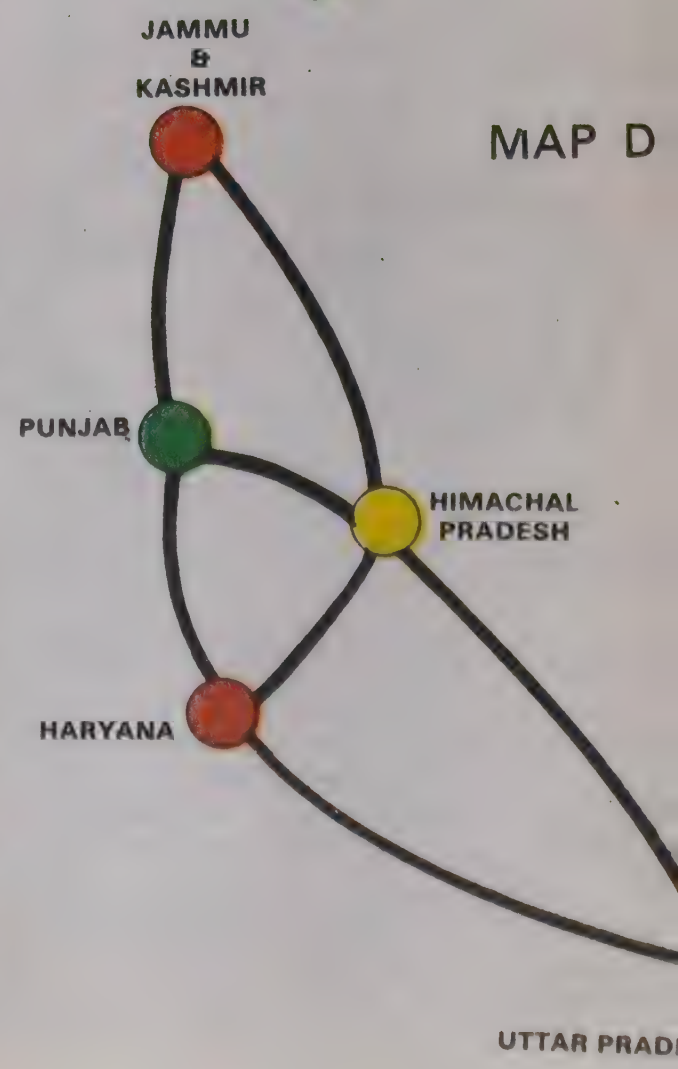


Fig. 2 The 'two colour theorem' states that, if a flat map could be drawn entirely of straight lines which begin and end at an edge, it could be coloured in two colours without having any adjacent areas of the same colour. The three figures below demonstrate the theory. The first flat map is in two colours. When a line is added (second map), two colours still suffice. This is shown in the third map. The colours below the line remain the same, while all colours above the line have to be *reversed*.

A further interesting observation is that, drawing a map on a plain piece of paper or a sphere is one and the same thing. The similarity is evident from what is known as stereographic projection (Fig. 5, p. 36). Thus, the four colour conjecture can now be rephrased: "Every map drawn on a sphere is vertex-colourable in four colours."

Heawood now asked the question, why should we consider maps drawn on a sphere only? Why not maps drawn on, for example, a tea cup or a tenecoit ring? How many colours will have to be used for vertex-colouring of maps drawn on these different surfaces? Mathematicians, again, do not have too many different types of surfaces (Fig. 4, p. 34) in their terminology. They do not distinguish between an elephant, a guava or a sphere. All these are surfaces of *genus zero* to them. A tea cup with one handle or a tenecoit ring has a surface of *genus one*, while a sugar-bowl with two handles is a surface of *genus two*. Roughly speaking, mathematicians think of every three-dimensional object as if it were a tea cup with a number of handles attached to it. The number of handles is called the *genus* of the surface of the object. To

mathematicians, a sphere is the same as a tea cup without a handle and hence its genus is zero.

Heawood, in fact, posed a general problem. What is the smallest number C(S) of colours required, so that any map on a surface could be coloured in C(S) or less colours? He conjectured a general formula for C(S), namely,

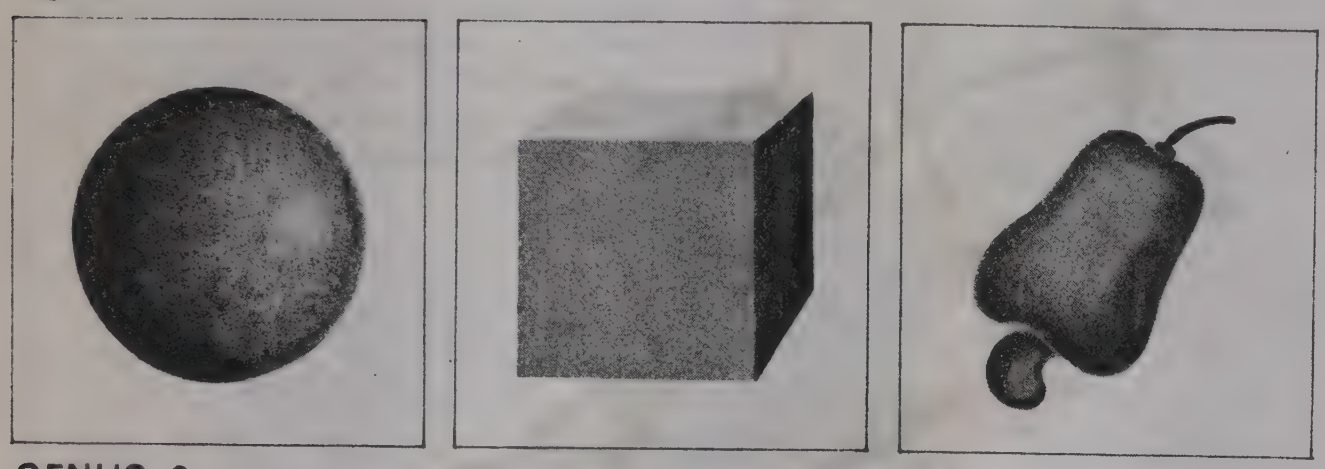
$$C(S) = \left[\frac{7 + \sqrt{1 + 48\ g(S)}}{2}\right],$$

where g(S) is the genus of the surface S and the brackets denote that we have to take only the whole number in the right hand side of the equation and forget the fractional part (for example, $[4 \cdot 56] = 4$). If $g(S) = 0$ (a sphere), the above equation precisely gives $C(S) = 4$, that is, the four colour conjecture. Thus, the four colour conjecture became a part of a much more general problem. The problem of proving the above equation for all surfaces S, later became one of the central problems in graph theory. Graph theorists called it Heawood's conjecture.

Heawood thought that he had solved the problem for all surfaces of genus more than zero. Unfortunately, he too had made some serious errors in his arguments, and thus the problem again remained wide open. Many mathematicians tried to prove Heawood's conjecture, in general, or the four colour conjecture, in particular, and in doing so made significant contributions to the development of graph theory. Finally, in 1968, J. W. T. Youngs and G. Ringel were able to show that Heawood's conjecture was true for all surfaces of genus *more than zero*. Alas, their methods did not work for surfaces of genus zero. Thus, the four colour conjecture continued to remain a mystery.

A person who made significant contributions to the four colour problem and related topics was H. Whitney who published his research papers on the subject around 1935-40. His approach was quite different in that he tried to link the problem with other mathematical theories and fields. His work is responsible for initiating a new theory, known as the theory of matroids. A promising feature of this theory is that it presents a unifying approach to the newly developing fields of graph theory, combinatories, finite geometries, etc — known in mathematical circles as finite mathematics.

Fig. 4



The objects in the same row in the above diagram can be obtained from each other by what mathematicians call "continuous" transformations. These are changes in the shape of a surface, which leave certain basic properties unaltered, and the surface, as a whole, unbroken. For a mathematician, the figure thus transformed has not changed at all. Roughly speaking, objects which can be turned into each other by means of twisting, bending, or other shaping, in other words without making or removing a hole, fall into the same class.

Thus, for example, a sphere cannot be turned into a ring by these transformations, but it can be deformed into a cube, or into a guava. Indeed a child performs such operations when he picks up a ball of modelling clay, squeezes it into the shape of a box or into a disc without tearing it.

The present solvers of the four colour problem, Apple and Hakin, strangely enough did not have to use the complicated techniques developed earlier. Their method is essentially a modification of Kempe's method. They have used about 400 pages of detailed, simple, logical arguments, and about 1,200 hours of computer time on some of

the best computers in the world, to arrive at their solution.

They have proved the four colour conjecture by what is called an "existence proof" — an argument which shows that something exists without necessarily producing it for inspection. To understand their proof, let us first see what Kempe had done way back in 1879-1880, and where he went wrong.

Kempe tried to prove the conjecture by showing that no flat map which required five colours exists. This would have proved the four colour conjecture. *If* there are such flat maps (requiring five colours), there must be a flat map requiring five colours and having a minimum number of regions. Such a flat map is called a minimal *five-chromatic* map. By definition, if such a map exists, any map having a smaller number of regions will require only four, or less, colours.

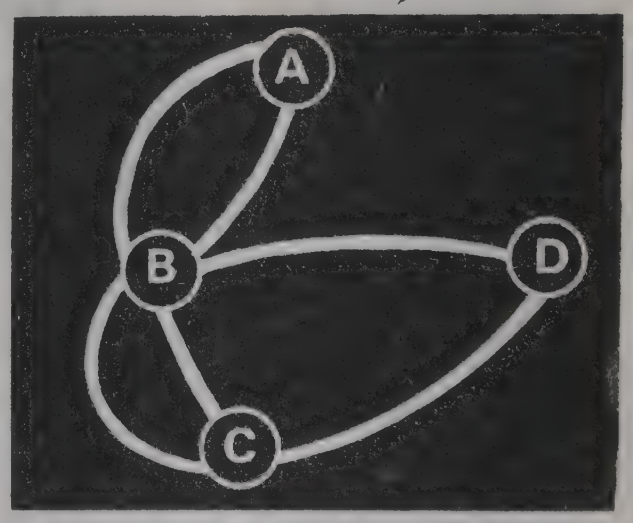
Kempe easily showed that no region in such a minimal five-chromatic map could have just two or three adjoining regions. For three, the argument went as follows : suppose a region *a* in such a map G has precisely three adjoining regions *b*, *c* and *d* (Fig. 7a, p. 37). Let us now construct a new map H, by amalgamating regions *a* and *c* in map G (Fig. 7b). The map H has clearly fewer regions. Since G was the *smallest* five-colour map, the new map H can be coloured in four colours. But in such a colouring of the total map H, only *three* colours need be used to colour the three regions *b*, *d* and amalgamated *a* and *c* (Fig. 7c). A colouring of map G in four colours is achieved by preserving the colours of all the remaining regions of H and colouring the triangular region *a*, with the colour not used in *b*, *c* or *d* (Fig. 7d). Thus, the minimal five-chromatic map G can be coloured in four colours — a contradiction ! Hence no region in a minimal five-chromatic map can be "triangular" like *a*, that is, with just three adjoining regions.

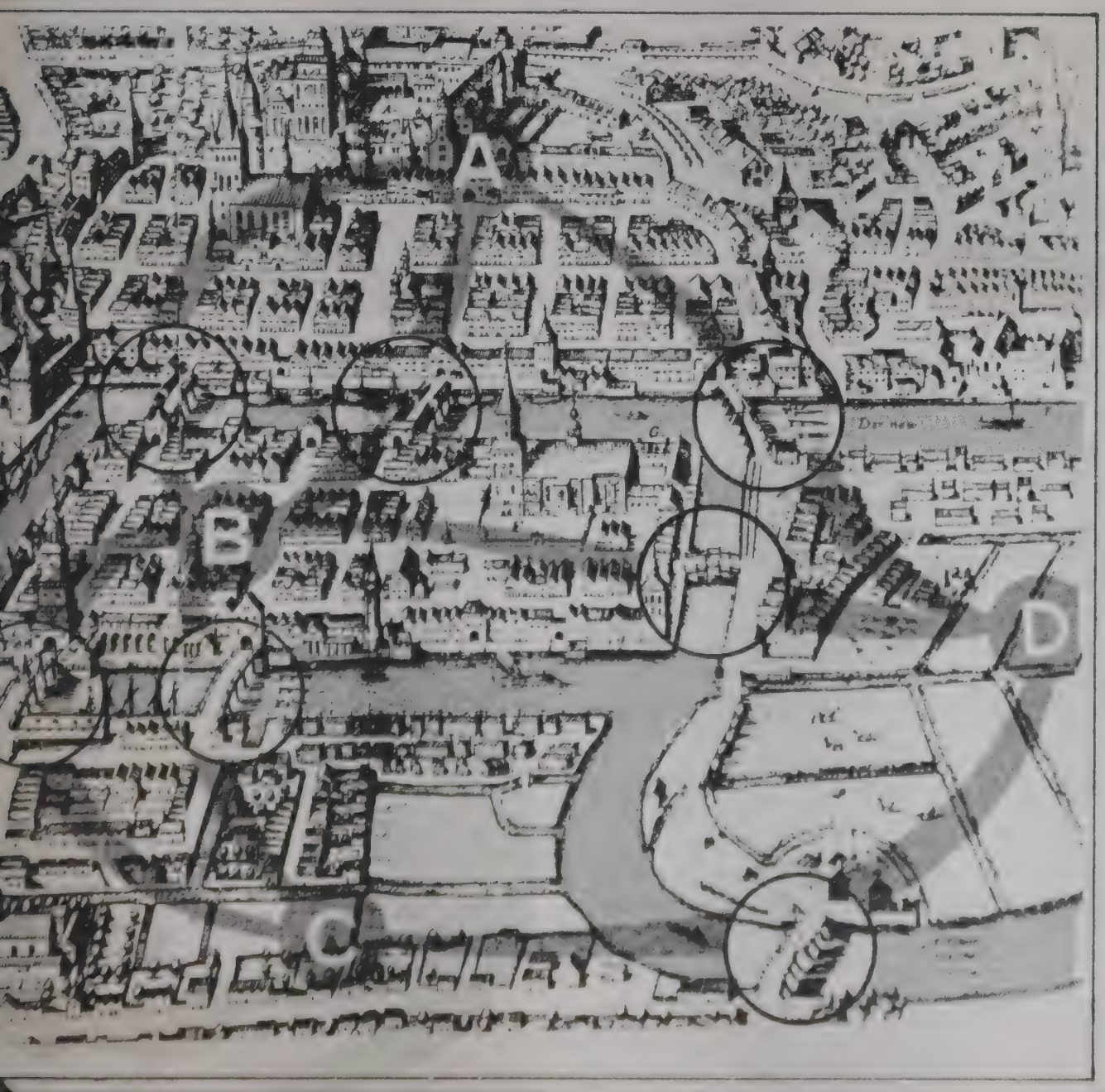
Kempe invented a more complicated argument (which we shall not discuss here) to show that no region

GRAPH THEORY AND THE KÖNIGSBERG PUZZLE

The present century, and in particular the last two decades, have witnessed the steady development of a new field of mathematics known as graph theory. Graph theorists essentially study the properties of figures which consist of points, some of which are joined by simple curves.

There are many factors underlying this new interest in the study of graphs. Perhaps, the most important have been the demands from the new fields of applications: game-theory and programming, communication theory, electrical networks and switching circuits as well as problems from biology and psychology. A number of popular puzzles can also be formulated directly in terms of graphs. Thus came the realisation that many such questions contain a mathematical nucleus of general importance.

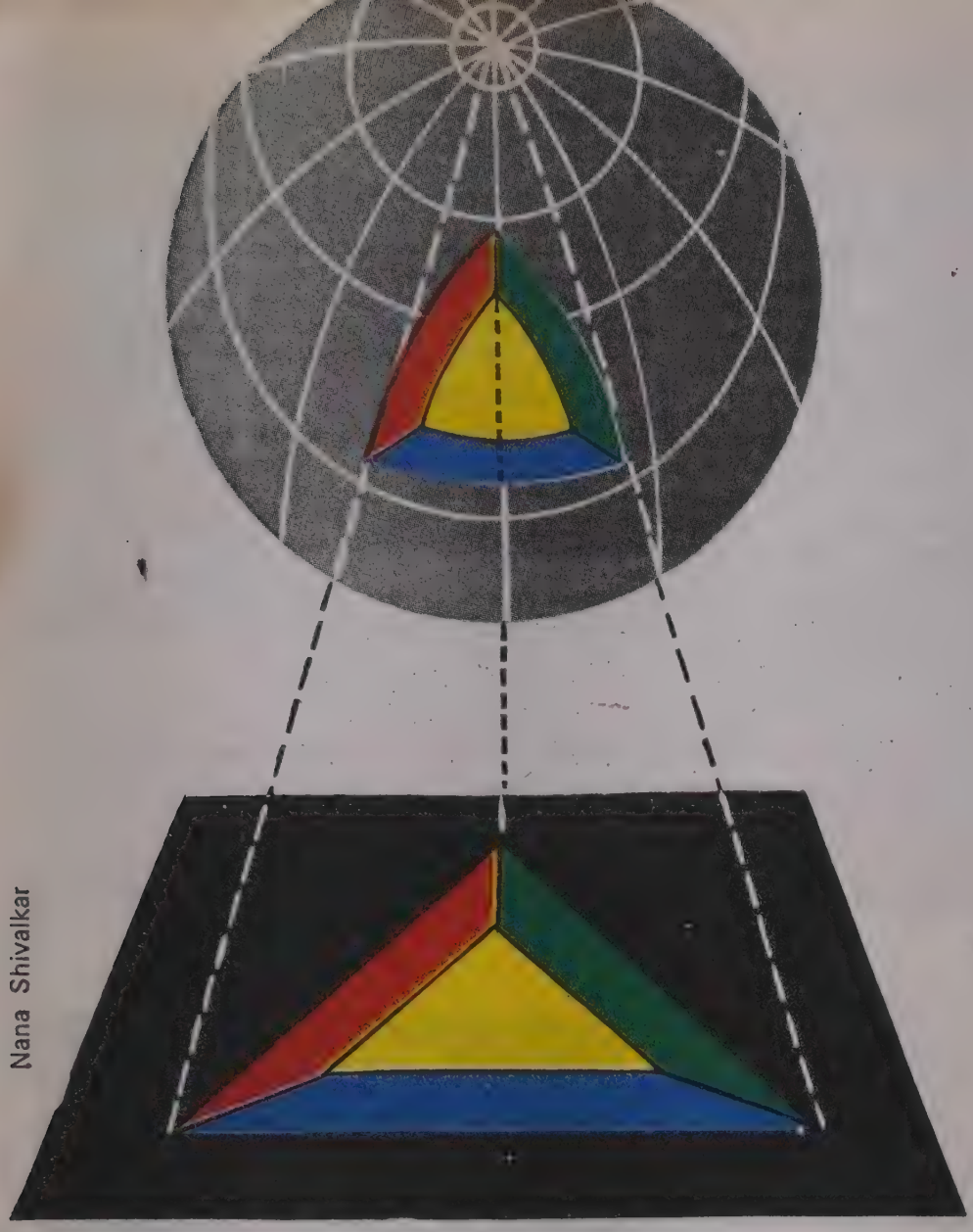




The origins of graph theory can be traced a couple of centuries back to a solution of a problem dealing with ancient bridges. It had been a traditional belief amongst the people of the Prussian city of Königsberg that it was impossible to cross all its seven bridges without *recrossing* one's route at some point. The Swiss mathematician, Leonhard Euler, demonstrated mathematically the validity of this popular belief. The old map (left) shows Königsberg and the river loop that devides it into four regions (marked A, B, C and D). Connecting these regions are seven bridges (in black circles). The heavy grey lines indicate all the possible routes between the regions using bridges. The diagram of the city (above) in which lettered points and lines correspond to those marked on the map shows why it is impossible to cross all the bridges without recrossing at least one of them.

In such a graph, some retracing is unavoidable whenever there are three or more points at which an odd number of paths converge — this was shown by Euler. It was a tribute to Euler's genius that he solved a problem in graph theory over 150 years before the subject came into its own as a distinct area of mathematical investigation.

N.M.S.



Nana Shivalkar

MAP E

Fig. 5 Stereographic projection on a plane, of a map drawn on a sphere, is obtained thus: take a point on the sphere. Call it north pole. Now join each point of the map on the sphere with the north pole and extend each of these straight lines to get a corresponding point on the plane. These points together give the projected flat map.

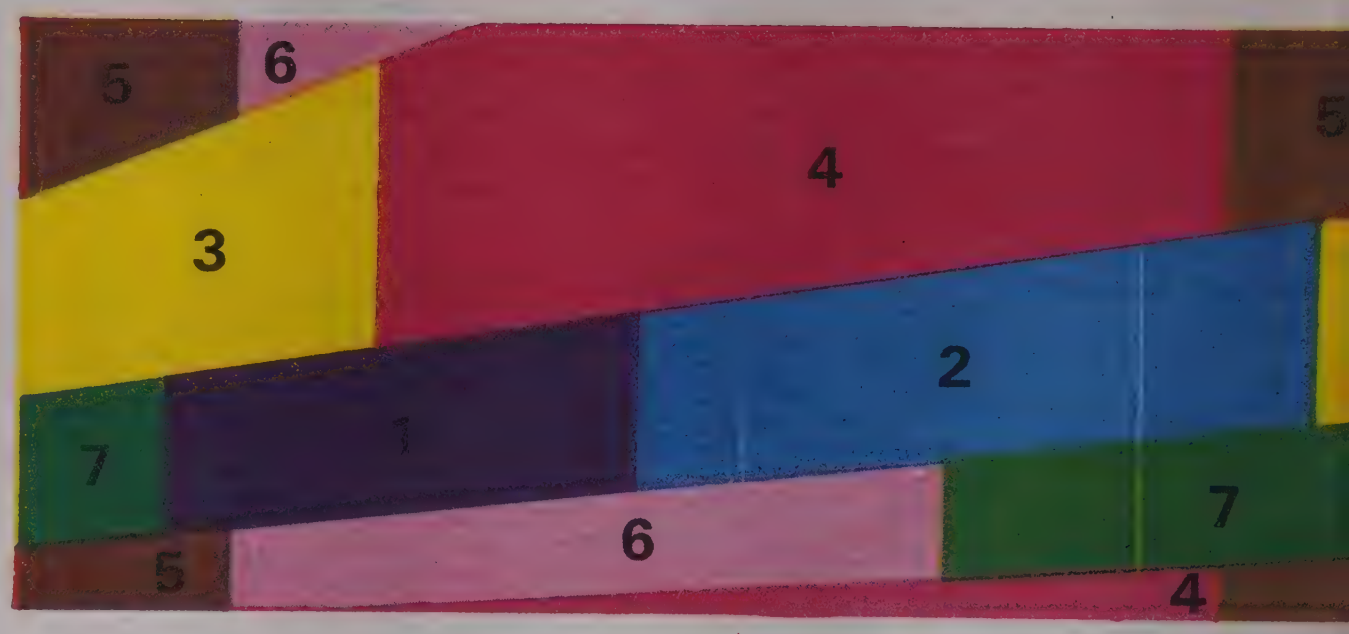
An interesting observation is that, the same map on a sphere can be drawn in many different ways on the plane by changing the location of the 'north pole'. Many a time, stereographic projection is used to draw maps of various parts of the earth in a geography book

in a minimal five-chromatic map could have precisely four adjoining regions. He thought he had also proved that no minimal five-chromatic map could contain a pentagon (a region with precisely five adjoining regions). If he would have done this, he would have solved the four colour problem, for it can easily be proved, and Kempe had done it, that *every flat map contains a region which has five or less adjoining regions.* However, there was a flaw in Kempe's argument for pentagons, as pointed out by Heawood.

Let us try to see, crudely though, what Kempe was doing. He proved that the set of figures consisting of regions with precisely two, three, four or five adjoining regions was *unavoidable*, in the sense that *every flat map contains at least one member of the set.* He tried to show that each of these figures was 'reducible', that is, if it occurred in a flat map which required five or more colours, then that map could not be a minimal map, and a smaller flat map existed which would require five colours. Thus, he attempted to show that there exists "an unavoidable set of reducible figures". But while he could prove the 'unavoidability' of his set of triangular, rectangular and pentagonal regions, there was a flaw, as we have said before, in his 'proof' of the reducibility of the pentagon.

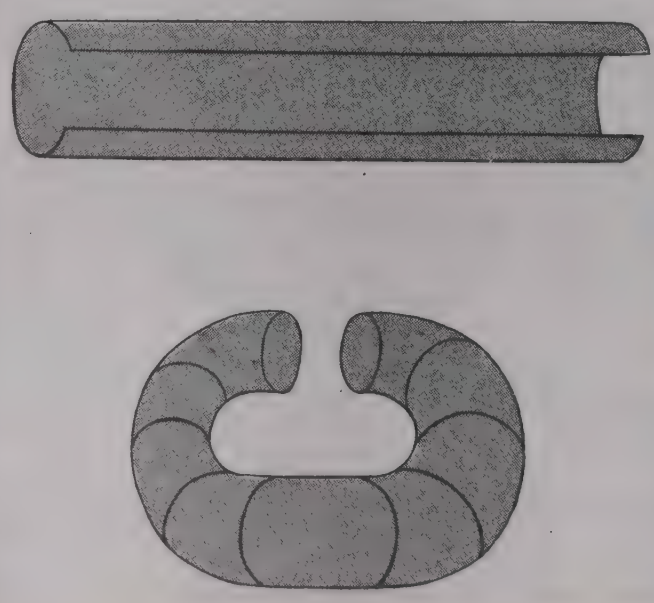
The idea of reducible figures has been developed further from 1912 onwards. G. D. Birkhonff, P. Franklin, C. E. Winn, A. Bernhart, H. Heesch, Jean Mayer and W. Tutte are among the many who significantly contributed towards this development. Even though a great deal of progress was made, no one had any reasonable intuition of a set of figures which was unavoidable and which contained only reducible figures. However, Apple and Hakin have succeeded in producing such an unavoidable set of reducible figures.

They have proved the four colour conjecture in two main steps. In the



MAP F

Fig. 6 Heawood's number $C(S) = \left[\frac{7+\sqrt{1+48}}{2}\right] = 7$ for a ring. In the diagram, a map (map F) with seven colours is drawn on a rectangular strip ABCD. If the opposite sides AD, BC and then AB, CD of the strip are pasted together (below, left), a surface with genus one, that is, a ring, is obtained (below, right). The map so obtained requires precisely seven colours. Heawood had shown that this is the best possible



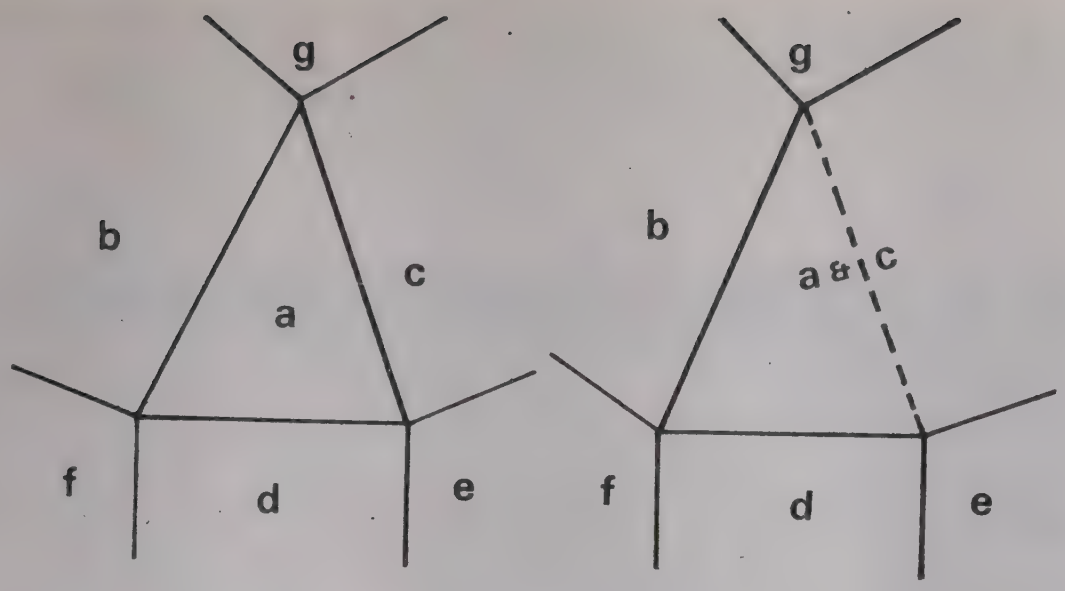
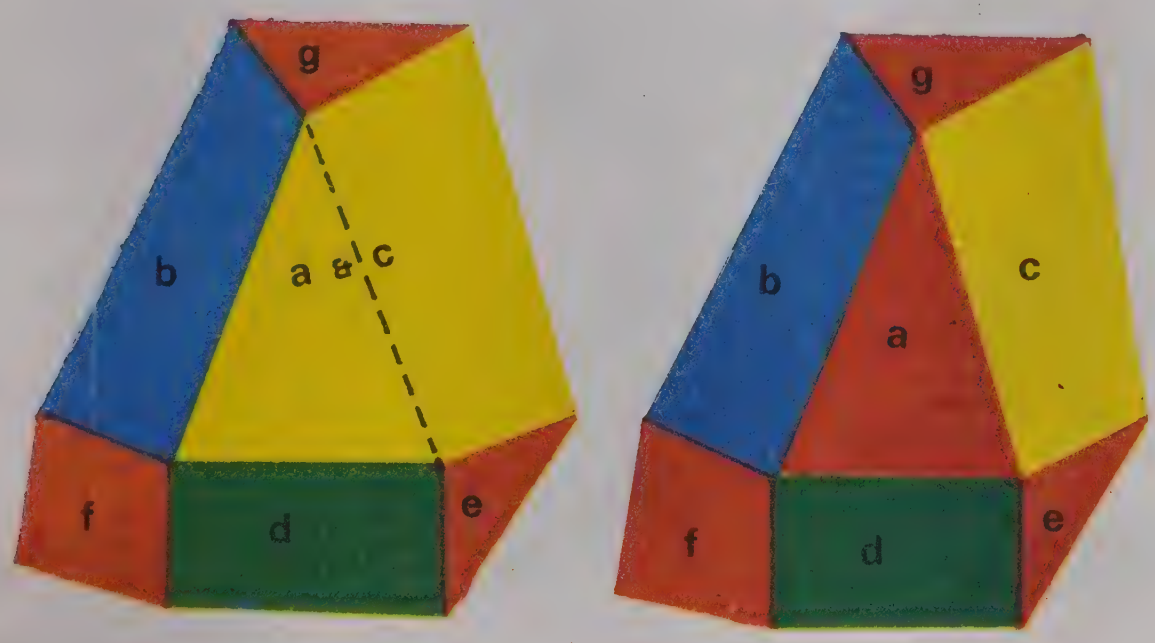


Fig. 7 (a) MAP G (b) MAP H

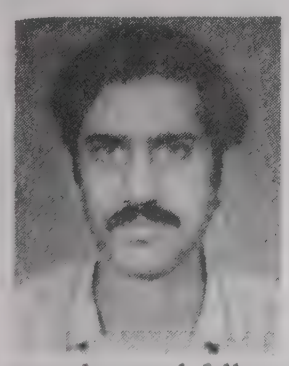


(c) MAP H (d) MAP G

first, they constructed a set of about 2,000 reducible flat maps, that is, figures which cannot occur in a minimal five-chromatic map. It is this part which requires detailed calculations and long hours of computer time. In the second step they have shown that, if any map does not have as a part any of the above 2,000 figures, then the surface on which it is drawn must have genus more than zero. In other words, every flat map has at least one of these 2,000 figures as a part. Thus, the set of these 2,000 figures is unavoidable. The unavoidability of the set is shown by a process first developed by Heesch — known as the principle of discharging (by analogy with the idea of moving charges in the electric network). These two steps together show that there is no *minimal* five chromatic map and hence that there is *no* flat map which requires five or more colours.

Four hundred pages is indeed quite long for a research paper in mathematics — perhaps, the longest so far. An interesting section of Apple and Hakin's paper is devoted to show that if one uses their methods, the length of the paper cannot be reduced very much. However, there might be some other method to prove the same conjecture. Mathematicians are still at it.

What are the reactions of graph theorists to their spectacular announcement? In a cafe, while amongst graph theorists, the author heard the following comment: "It is disheartening to see that the problem has been solved by simple arguments. It was thought that at least this problem of graph theory will require more sophisticated tools." Another comment was: "Who will verify these 400 pages of argument and 1,200 hours of computer time ?"



Navin M. Singhi (28) is a fellow at the School of Mathematics, Tata Institute of Fundamental Research, Bombay. After his PhD from Bombay University in 1974, he joined the Department of Mathematics, Colorado State University, USA, as a post-doctoral fellow (1974–75). During 1975–76 he was a visiting assistant professor at the Ohio State University, Columbus, Ohio, and later visiting professor at the University of Waterloo, Canada. His special field of interest is combinatorial mathematics. *Recommends reading:* **1.** Harary, Frank 1961 *Graph Theory.* Addison–Wesley Publishing Company. **2.** Chin, W. G. & Steenrod, N. E. 1966 *First Concepts in Topology.* L. W. Singer Co. **3.** Ore, O. 1967 *The Four Colour Problem.* Academic Press.

IN LIGHTER MOMENTS

Despite the iconoclasm of Islam, the main factor behind Islamic astronomy was astrology. And the astrology was also the final cause of astronomy's death. The Islamic or Arab school of astronomy which was born in Baghdad Academy in the ninth century AD, reached its peak at the Samarkand observatory set up by Ulugh Begh, grandson of Tamerlane or Timur. Here fresh tables of planetary movements were prepared and a new catalogue of more than 1,000 stars was drawn up. It was here that, with the help of these tables and catalogues, Ulugh Begh cast his eldest son Abdul Latif's horoscope, which foretold that he would kill his own father. To be on the safe side, the ruler-astrologer disowned and exiled Abdul Latif and made his younger son heir to the throne. However, with the help of some neighbouring chiefs and emirs, Abdul Latif raised an army, attacked and destroyed Samarkand and got his father killed.

* * *

Edward Jenner, the father of vaccination, was a thorough disciple of John Hunter. Once at a dinner party, people were discussing which part of a candle flame was the hottest. Jenner, then quite young, recalled his teacher's injunction — "Why think? Why not try the experiment?" And without a word, he put his finger at the burning flame's base and found that he could retain it in that position for a short while. But when he repeated this just above the tip of the flame, he could not hold his finger there even for a second. And so he confidently announced : "There, gentlemen, the question is settled."

* * *

Much before Robert Koch discovered the bacillus of tuberculosis (in 1882), Jean Antoine Villemin, also of France, had a hunch in 1867 about the existence of such a germ. His theory "resembled Pasteur's picture of germs floating about in the air". Villemin's personal rival and malicious opponent, one Dr. Pidoux, ridiculing this theory, ironically said, "If TB is due to a microbe, then all we doctors have to do is to set our nets to catch the germs of TB and find a vaccine !" However, poor Pidoux could not imagine that his comment belied its intended sarcasm and would prove to be truly prophetic.

* * *

When the Nazis came to power in Germany, one of their several missions was to end communism. They subjected many German scientists to persecution. The American geneticist, Hermann Joseph Muller, issued a strong protest declaring that to scientists the Nazi doctrine of racism was as reprehensible as the "deadly regimentation of ideas that any dictatorship imposed . . . Good or bad genes are not the monopoly of particular people or of persons with features of a given kind."

S. N. MUNSHI

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Dattaram ITI-128

Solar-powered crop sprayer

A solar energy-powered light crop sprayer has been developed by a team of scientists and engineers at the International Institute of Tropical Agriculture (IITA) at Ibadan in Nigeria. The work was part of a package of low-applied-energy farming systems aimed at raising farm productivity without using heavy machinery.

A simple solar energy collector, about 0·093 sq metre (a square foot), can provide the power needed for either herbicide or insecticide spraying. The solar energy falling on a square metre of sunlit surface is about 1,000 watts (1 kW). The collector is equipped with 38 wafer-thin silicon photo-voltaic cells which provide more than five watts of power in average sunlight — much more than what is needed to operate the spinning disc of the sprayer.

The surplus power charges a battery of eight nickel-cadmium cells in the handle of the sprayer to provide power even through patches of cloudy dull weather. At the IITA, in continuous operation for eight hours a day and seven days a week, the batteries were found as full of charge as on the first day. Besides storing the excess energy, the Ni-Cad cells also function as a voltage stabiliser, maintaining a constant 7,000 rpm.

The solar panel rests lightly on the operator's shoulders like a very light 'sunshade' — the panel and the shoulder-supports weigh only 1·2 kg. The batteries get charged as soon as the wiring from the panel is plugged into the sprayer in the open field. The motor spinning the sprayer disc operates when switched on for spraying. Admittedly, the device is somewhat of a gimmick at its present stage of development, but the small size of the solar generator emphasises the very low applied energy involved.

RAY WIJEWARDENE

[Mr. Wijewardene is an agricultural engineer at the International Institute of Tropical Agriculture, Ibadan, Nigeria.]

A super sweetener

A sugar derivative which is 500 to 600 times sweeter than sugar has recently been reported. The new derivative which is obtained by chlorination of sucrose using thionyl chloride does not have any after-taste associated with amino acid-derived sweeteners such as saccharin and cyclamate. The compound, 1′, 4, 6, 6′ tetra chloro-1′, 4, 6, 6′-tetra deoxygalacto sucrose, was discovered during a study of stereospecific chemical reactions of sucrose derivatives. The compound has the four most reactive hydroxyl groups of sucrose replaced by chlorides.

None of the extensive health and safety tests required to market a food additive has been done on the compound yet. The tests are very necessary, as a number of organic compounds are known to be carcinogens and many more have become suspect in recent years. In the end, even if the compound does not turn out to have commercial value, its development will be important in understanding what makes compounds taste sweet. An enhancement of sweetness by selective substitution by chlorine has not been observed before in sucrose or any carbohydrate.

V. C. MALSHE

Coal solubilisation by grafting

Though coal is the most abundant of the fossil fuels, there are certain problems in utilising it. The high sulphur and ash content make it inefficient and cause sulphur dioxide and particulate pollution. To reduce the sulphur and to get rid of the ash, attempts are being made to liquefy coal. Hydrogenation of coal under high pressure and also its conversion to methanol have been extensively studied but still remain uneconomic propositions.

The latest approach is to solubilise coal by grafting monomeric compounds on anthracite or bituminous types of coals. Though the technique is frequently used for solubilising "difficult-to-dissolve" polymers, it can now be applied to coal (*Chemical & Engineering News*, **55,** 26, 1977).

In this process, graft initiators and monomers are slurried with powdered coal. The grafting takes about six hours. To liquefy the product, solvents derived from coal or petroleum can be added. The resultant liquid resembles fuel or crude oil and can be transported and stored in much the same way.

The choice of the monomer is important to the solubility of the treated coal. Non-polar substituents such as methyl, ethyl and propyl groups enhance the solubility in aliphatic hydrocarbons while phenyl, methyl phenyl and similar aromatics make coal soluble in aromatic solvents.

Since the process takes place at atmospheric pressure and mild temperature conditions, capital investment in plant and equipment will be much lower than that needed for techniques like hydrogenation. The important parameters which will decide the cost are the monomer used, the amount of monomer required, and the extent of conversion of the coal to the soluble form. These are being studied further. The sulphur in the coal is not solubilised to a large extent.

The solubilised coal so obtained can be used as a liquid fuel of low ash content. Mixed with kerosene, it can be a substitute for diesel. It may also be used as a chemical feedstock. India has very large coal deposits, and the process should be very suitable if an integrated facility is set up at the coal mines.

V. C. M.

WHAT ARE WE ADDING TO OUR FOODS?

K. K. G. MENON

Additives serve an enormous range of functions in today's foods. Some improve the quality, taste, appearance and appeal of the food; some inhibit staling, moulding or bacterial decomposition of food; some prevent the browning and deterioration of fruits, and some improve their flavour and texture and extend their usefulness. Increasing urbanisation has necessitated transport of food over great distances and storage for great lengths of time and this, in turn, has promoted wide use of a variety of food additives as preservatives, flavouring agents, antioxidants, colourants, stabilisers, foaming agents, etc. And, then, people today increasingly go in for more 'convenient', more sophisticated, more flavourful and more exotic foods which naturally involve the use of a large number of food additives.

However, the advent of food additives has not been an unmixed blessing. Many unscrupulous manufacturers have in the past used additives to upgrade deceptively the quality of foods or have doctored foods to attract wider consumer acceptance. Several food additives, which were widely used earlier, have also been either restricted for use or prohibited as a result of better knowledge about their probable long-term effects. The list of such additives is staggering; it includes, for example, chloracetic acid for preserving wines, sulphite for reddening meat, nitrogen trichloride (agene) for bleaching flours, dulcin (4-ethoxyphenyl urea) as an artificial sweetener, coumarin in synthetic vanillin flavours, saffrole and cobaltous salts in beer, diethylstilbestrol in animal and poultry feeds and a host of food colours. The list keeps growing. While this has shaken the confidence of the public in the safety of food additives, it has also given rise to a number of scare stories and headlines in newspapers from time to time. On balance, however, the many beneficial effects of food additives far outweigh the very few instances of harm resulting from their improper, excessive or careless use.

According to the Food and Agricultural Organisation (FAO) and the World Health Organisation (WHO), a food additive is "any substance not normally consumed as a food by itself and not normally used as a typical ingredient of the food, whether or not it has nutritive value, the intentional addition of which to food for a technological (including organoleptic) purpose in the manufacture, processing, preparation, treatment, packing, packaging, transport or holding of such food, results, or may be reasonably expected to result (directly or indirectly), in it or its by-products becoming a component of or otherwise affecting the characteristics of such foods". It does not include "contaminants", or substances added to food for maintaining or improving nutritional qualities.

The main purpose of, and the only justifications for, any food additive is that: (1) it brings some benefit to the consumer, (2) it is absolutely essential technologically in manufacturing a food product, (3) it is not used to disguise faulty processing or handling techniques, (4) it does not substantially reduce the nutritive value of the food and, most important, (5) it does not pose any health hazard for the consumer. Food additives, in general, should only be used when they can contribute to the preservation of food by maintaining its nutritive quality or keeping quality or stability or improve its organoleptic acceptance (that is, its 'appeal' to the consumer). Occasionally, food additives are also used as necessary ingredients for foods manufactured for special dietary needs, for instance, saccharine for diabetics or low-calorie foods. Since safety is the prime consideration, one has to consider and carefully evaluate the benefits and risks. Equally important, such evaluations must consider not only the amounts of an additive under conditions reasonably related to its intended use but also related to its occasional unintentional 'misuse'.

It has been estimated that we use about 20,000 chemicals as food additives. Unfortunately, our ability to interpret the metabolic significance and repercussions of these materials has lagged far behind our ability to find use for them. While this has caused considerable concern over the biological safety of these materials in the long run, the prohibition of certain food additives in one country and their permitted use in others have also created a lot of confusion in the minds of consumers and legislators. And many substances, which have been commonly used with no indications of any untoward reactions, have now been questioned by researchers and found not to meet all the criteria of safety. These include turmeric, amaranth, saccharine, etc. In fact, it may be truly stated that substances which are less well-studied appear to be about the safest at the moment, and Government regulations on the subject are severely criticised by those who know them best and as widely revered by those who do not. It is fortunate, perhaps, that fashions in food additives keep changing, so that an individual is unlikely to be exposed to the same chemical over his entire lifetime.

The whole problem of safety of additives is, in fact, very complex. And popular and sensationalised scientific articles with provocative titles do not make it any less difficult. The Food and Drug Administration (FDA) in the USA at present presumes every new substance to be hazardous unless proven safe, and the onus of proof is on the manufacturer. The position in India is similar.

The problem is, absolute safety is really an abstraction. Despite the availability of new toxicological tools, there is no way of proving the absolute safety of a material. Short of totally prohibiting a material, one has to base one's judgments on practical criteria, concentrations of the questionable chemicals present and a proper risk-benefit assessment. In assessing risk, due consideration should be given to aspects of *toxicity* — that is, the *capacity* to produce injury — and to aspects of *hazard* in use — that is, the *capacity* to do *harm at likely human* intake levels. And, then, appropriate tests must prove beyond doubt that the substance is not carcinogenic (cancer-causing) or teratogenic (that is, embryo-toxic).

But what are " appropriate " tests? There is a great deal of argument about this. How does one determine the possibility of chemical carcinogenesis? Is it just the presence of a single molecule of the putative carcinogen, or is it related to dose as in other toxicological evaluations? Has 'zero' tolerance (the concept that any material that is toxic should be totally absent, and should not be tolerated at all) any biological relevance?

The Delaney clause in the food additives amendment in the USA (1958) states that no chemical can be added to foods if in *any amount* it produces cancer when ingested by animals or man. Supporters of the Delaney clause emphasise that " although some people claim that certain specified low levels of carcinogens are harmless, this has never been proved. We just don't know how to establish safe tolerances for carcinogens ". On the other hand, the opponents are convinced that " threshold levels of carcinogenic activity do exist and that safe levels can be determined ". In any case, there has to be " no effect " levels of carcinogens in man. Otherwise, every one could expect to get cancer eventually because every one is exposed daily to small doses of environmental and food carcinogens — background radiation, natural oestrogens, sunlight and polycyclic hydrocarbons in vegetables. I would not go into this controversy any further. Let me say, by and large, most food additives in common use

TOXICOLOGY OF FOOD ADDITIVES

Unlike drugs, food additives, are consumed by a non-targeted population, including the vulnerable groups. They are not administered under the supervision of a doctor in a specified dose for a specified time to specific individuals. Drugs are administered at biologically effective levels and are accompanied by an element of risk, which is counter-balanced by the benefit to be gained. Food additives, on the other hand, are intended to have absolutely no biological effects, except those of normal nourishment. Further, they may be consumed throughout an individual's life. And while, with drugs, one is often able to look for their specific effects and specific organ sites to notice these effects, with food additives, one cannot be selective in the histopathological examination of tissues.

In drugs, toxicity is mainly a medical problem. In foods, the problem is much more widespread, and becomes a public health issue. In the case of drugs, the physician acts as a safety barrier between the producer and the consumer; he has the responsibility of weighing any hazard against the potential benefit to the patient. With food additives, however, the consumer is not consciously aware, nor is there a mechanism to make him aware, of the potential hazards. The consumer takes it for granted that what he buys is good for him and his health and well-being is safeguarded by the " authorities ".

Because of this, a grave responsibility is placed on scientists engaged in food technological work, on industries using food additives, and on the Government and other regulatory authorities responsible for clearing food additives for general acceptance, for monitoring the levels of food additives and for controlling the proper use, quality specifications and labelling of foods. As more and more chemicals are being used in the food chain — pesticides, fertilisers, growth stimulants, preservatives, processing aids, colouring agents, thickeners, antioxidants and so on — and as we are getting more and more conscious of the harmful effects of some of these commonly used agents, the government and the regulatory agents are becoming more and more strict and exacting about scientific and toxicological data on the usefulness and harmlessness of food additives.

TESTING OF FOOD ADDITIVES

The composition of food additives, including probable impurities, the conditions and the extent of their usage, keeping in mind differences in dietary habits in different countries, their possible misuse and their biological properties in a wide range — all these factors have to be considered in evaluating the possible hazard and making a judgment on the safety in-use of a food additive. For this, besides the physical and chemical specifications of the food additives, the following biological information is sought.

Acute toxicity data by oral administration or by injection in rats, mice and one additional species. Here one has to be careful in looking for any untoward effects from the condition of the animal, by a complete and close examination of a large number of tissues.

Short-term studies, usually by feeding for 90 days in rats or mice and in an additional species for a period of at least 10 per cent of its life span. In this case, a 1,000-fold margin of safety on " no effect " levels in animals has been suggested for extrapolation of animal data to humans.

Chronic or long-term studies, usually two-year tests in rats including complete histopathological data, toxicity, fertility (in multi-generation studies) and carcinogenecity. In this case, a 100-fold marginal safety on " no effect " levels in animals has been suggested for humans.

Besides these, *metabolic effects* of the additives on various enzyme systems such as serum and tissue enzyme levels, absorpton, digestion and excretion patterns of the additive and its metabolites, etc are also necessary. These tests require sophisticated technologies and, apart from animal use facilities, a good deal of inter-disciplinary collaboration among biochemists, physiologists, histochemists, pharmacologists, electron microscopists and ecologists and analytical chemists. And in extrapolating the results of animal studies to man, the possible differences in the action of intestinal microflora and differences in metabolism between the two species as well as individual variations in the response to additives should be considered.

STEPWISE ASSESSMENT OF SAFETY OF A FOOD ADDITIVE

A. CHEMICAL SPECIFICATIONS
1 Identity
2 Purity
3 Characterisation of impurities

B. BIOCHEMISTRY
1 Absorption
2 Digestion
3 Distribution
4 Metabolism
5 Utilisation
6 Elimination

C. PROBABLE USE
1 Daily intake
2 Effects on food
3 Nature of residue
4 Possible toxic products
5 Compatibilities

D. BIOLOGICAL EFFECTS
1 Acute toxicity
2 Subacute toxicity
3 Chronic studies
4 Multigeneration studies
5 Mutagenicity, embryo-toxicity, carcinogenicity studies
6 Studies in different animals

E. HUMAN STUDIES
1 Acceptability in foods
2 Monitoring in humans in zoned distribution
3 Epidemiological information
4 Use conforming to ADI

K.K.G.M.

today do not pose any carcinogenic hazard to the best of our knowledge and experience.

Classification of food additives

The following classes of food additives are allowed in various foods: (*a*) preservatives, (*b*) antioxidants, (*c*) emulsifying agents, stabilisers and thickeners, (*d*) sequestering and buffering agents, (*e*) bleaching and maturing agents and starch modifiers, (*f*) food colours, (*g*) flavouring agents and flavour boosters, (*h*) nutrient supplements, (*i*) non-nutritive and special dietary sweeteners, and (*j*) anticaking agents.

Preservative is a " substance which when added to food is capable of inhibiting, retarding or arresting the process of fermentation or decomposition of the food ". Under the Prevention of Food Adulteration (PFA) Rules, there are two classes of preservatives. Class I are those on which there is no restriction on the quantities to be used (unless provided in the rules); Class II are those which are permitted within specified limits in specific foods and have to be declared on the labels. Common salt, sugar, glucose or dextrose, spices, vinegar, honey and edible oils are Class I preservatives. Examples of Class II preservatives are benzoic acid, methyl or propyl parahydroxy benzoic acid, sulphur dioxide, nitrates and nitrites, sorbic acid, propionic acid, lactic acid and acid calcium phosphate. When more than two Class II preservatives are used in conjunction, their individual amounts should be fixed in such a way that their total amounts do not exceed the equivalent permissible levels of each.

No doubt, preservatives are unavoidable because of the time-lag involved in taking agricultural products from the farms to the consumers' tables and to avoid wastage of food, but caution is needed in their use, particularly in foods meant for children. In adults, many of the 'added' preservatives are metabolised or otherwise disposed of by the detoxification systems of the liver and the kidneys. Since these mechanisms are not fully developed in infants and children, one has to be particularly careful about the use of preserved foods in the dietaries of children. Benzoic acid, sulphur dioxide, sorbic acid and nitrites and nitrates are all culpable in this regard.

The case of nitrites is typical. Nitrite is primarily added to meat to produce the typical red colour of cured meat products; it has also significant preservative effect, particularly against *Botulinum*. The acute and sub-acute toxic effects of nitrites (vasodilation, lowering of blood pressure and formation of methaemoglobin, that is, oxidised haemoglobin) are well known. Treatment of green vegetables with fertilisers can result in high contents of nitrate/nitrite in leafy vegetables eaten raw. Recently there have been instances of methaemoglobinemia and death in babies in West Germany following the ingestion of spinach containing nitrates. Several foodstuffs such as fish meal, cheese and meat can contain nitrosamines produced by the reaction of nitrite with secondary or tertiary amines. Nitrosamines have been shown to be carcinogenic in a number of animals and there is a need to restrict the intake of nitrate/nitrite in diets, specially for children.

Antioxidants are " substances which when added to food retard or prevent oxidative deterioration of food but do not include sugar, cereals, oils, herbs and spices ". Antioxidants used in foods are also of two categories: Class I includes lecithin, ascorbic acid and tocopherols, for which there are no specific limits and which can be added according to the requirements of good manufacturing practices; Class II includes gallates, butylated hydroxy anisole (BHA) and butylated hydroxy toluene (BHT), resin guaiac, and citric and tartaric acids which are generally allowed in foods at specified levels. In ghee and butter, only BHA and BHT may be added. The amounts allowed range from 100 to 200 parts per million (ppm), depending on the substance. BHA and BHT have been widely used as antioxidants in foods, for instance, in oil and vanaspati. Whereas BHA is reportedly excreted in the urine, BHT is excreted very slowly and incompletely. This has led to the suspicion that BHT may be stored in the tissues; it would be better to restrict its use in food for human consumption as far as possible. In fact, BHA has been extensively permitted for use in several major countries but not BHT, though, technically, both BHA and BHT have been given temporary (or tentative) toxicological clearance for use in food by the FAO and the WHO.

Emulsifying agents and stabilising agents mean " substances which when added to food are capable of facilitating a uniform dispersion of oils and fats in aqueous media or vice versa ". A wide variety of substances have been used for these purposes — many gums, albumen, gelatine, starches, proteins and derivatives of fats and of cellulose — in products such as margarine, ice-cream, jellies and jams. Under the PFA, only certain emulsifying agents can be used in milk and milk products. In any case, no emulsifying agent can be used in a food except where its use is specifically permitted. There are no limitations on the general use of natural gums such as acacia, guar and Carob bean but there are restrictions on the permissible maximum use of other gums such as alginic acid, carrageenan and synthetic cellulose and fatty acid derivatives. The acceptable daily intakes (ADI) of a number of these substances are given in Table I.

TABLE I: EMULSIFIERS, STABILISERS AND THICKENERS

	ADI (mg/kg of body weight)
Sucrose esters of fatty acids	2·5 (temporary)
Sucroglycerides	25 (temp)
Polyglycerol esters of fatty acids	25
Polypropylene esters of fatty acids	25
Mono and diglycerides of fatty acids	Not specified
(Acetic, lactic, citric, tartaric) esters of glycerol	50
Sorbitan esters	25
Carob (locust) bean gum	Not known
Tamarind seed flour	Not known
Gum ghatti	Not known
Karaya (*Sterculia*)	Not known
Guar gum	Not limited
Gum arabic (acacia)	Not limited
Agar	Not limited
Seaweed extracts (Alginic acid)	25
Pectins, amidated pectins	25
Cellulose derivatives	25
Xanthan gum	10

Sequestering agents are " substances which prevent adverse effects of metals catalysing the oxidative breakdown of foods by forming chelates, thus inhibiting discoloration, off-taste and rancidity ". Sequestering agents commonly used in foods are citrate, gluconate, phosphates and tartarates. These occur very commonly; they do no harm when added to foods in small amounts. However, in certain foods such as canned fish and meat and carbonated beverages and dressings, ethylene diamine tertra acetate (EDTA) is being used in the USA though it is not permissible in India.

Buffering agents are used to counteract acidic or alkaline changes in foods during storage or processing; they improve flavour and increase the stability of foods. The usual buffering agents used are certain organic acids like citric, acetic, malic acids, and alkalies such as sodium hydroxide or carbonate and salts. These are generally innocuous but should not be used in manufacturing practices to deceive the consumer by providing superficial appearance of quality or colour.

Bleaching agents are used to give foods a more attractive coloration — for example, bleaching of wheat flour. *Maturing agents* are used to induce changes which would otherwise normally occur over a longer period of time; bromates, for instance, are used as dough conditioners. A number of starches are also being used nowadays in cakes and other preparations to enhance the quality and to arrest the degradation caused by fruits and other additives in cakes. In our country, the use of these materials is minimal and is not a subject of public concern.

Food colours

In India, the addition of colouring matter to any article of food except as specifically permitted by the PFA rules is prohibited. Also, the colouring agent added has to be clearly mentioned on the label. Caramel made by other than the ammonia process may be used without label declaration, but caramel made by the ammonia process can be used only in quantities less than 2,000 ppm in foods. The natural colours and the synthetic colouring matters which may be used in foods in India are given in Table II.

In the use of colours, as in the case of other food additives, different countries arrive at different conclusions on admissibility and use. Each of these conclusions may be right from the individual country's point of view, but it definitely confuses the consumer — he does not understand why he is eating something that is banned in another country. For example, Red No. 40 (Allura Red) is used in the USA but is not permitted in Canada. Green S is not permitted in the USA but is allowed in the UK and India. Quinoline Yellow is allowed in the UK and Germany but not in the USA and India. Ponceau 4R is allowed in the UK and India but not in the USA. There are quite a few colours such as Indanthrene Blue RS, Patent Blue 5 and Ponceau 6R which are allowed in other countries but not in India. We also put a general limit of 0·2 per cent for aromatic amines in synthetic colours.

Amaranth (FD & C No. 2) is one of the most widely used colours. It has been recently banned in the USA, but is permitted in Canada and the UK. There has been some concern over the carcinogenicity and teratogenicity of amaranth based on Russian observations that it caused foetal damage in rats. Subsequent experiments have failed to produce unequivocal results — particularly those on teratogenicity recently carried out by the FDA and the National Center for Toxicological Research in the USA. The overall view seems to be that so far data concerning the potential hazards of this colour have not been definitive and do not justify prohibiting or restricting its use. Before the recent ban in the USA, they were using more than half a million kg of this colour per year. The concern over carcinogenicity and teratogenicity due to amaranth appears to have arisen from the use in animal tests of samples of amaranth with specifications different from those established by the (US) FDA.

The FAO/WHO temporary acceptance for daily intake of 2·5 mg per kg body-weight of turmeric works out to only about 150 mg of turmeric per 60-kg man per day or approximately 1·5 to 2 g of curry powder per day. These figures appear to be too conservative as many people in India take much larger amounts of turmeric and there have been no reports yet of any untoward effects.

Flavouring agents produce a predominant odour, which possibly affects taste as well. Flavours may be natural or artificial. In India, flavouring chemicals are not expected to be added in foods in amounts exceeding 300 ppm. Two flavouring agents, coumarin and dihydrocoumarin, are totally prohibited. Certain substances such as quinine, agaric acid, hydrocyanic acid, solanine and saffrole, which occur either naturally in food or are added to foodstuffs are allowed only in very small amounts (1 to 10 ppm except for quinine which is allowed up to 300 ppm in alcoholic beverages). The FAO and WHO also specifically prohibit the use of any part of the following plants: (1) liverwort, (2) deadly night-shade, (3) Lily-of-the-Valley, (4) sassafras, and (5) roots of the pomegranate tree, to mention only a few.

Because the number of flavouring agents used in foods is so vast, most countries find it impossible to enumerate, classify and establish permissible levels of their usage based on toxicological data. Such data are not available for most of these compounds. Most countries, therefore, have a list of prohibited flavouring agents rather than a list of permitted ones, though the European Economic Community (EEC) and the USA are working towards the preparation of a list of permissible flavouring agents. The recent EEC list contains 495 natural flavouring substances, 692 artificial flavouring substances which may be added to foodstuffs without hazard to public health, 284 artificial flavouring substances which are permitted to be added *temporarily* to foodstuffs without hazard to public health, 243 artificial flavouring substances *not*

ACCEPTABLE DAILY INTAKE OF FOOD ADDITIVES

The enzyme systems for the metabolism and disposal of chemicals added to food are not fully developed in infants and children. This demands particular caution in permitting food additives in foods for infants and children. Therefore, irrespective of the indicated acceptable daily intake (ADI), food additives are not necessarily cleared or automatically permitted in children's foods.

The acceptable daily intake in the FAO/WHO recommendations are given in terms of mg/kg body-weight, but when one converts it in terms of acceptable concentrations in foods, one runs into several difficulties. For example, the ADI in terms of mg/kg body-weight should not be considered in terms of a 70-kg man. Most of the people in India are of lower weight; the total intake should, therefore, be correspondingly less. Also, persons with lower body-weights may consume the same amount of food as a 70-kg man. Hence, the transfer of ADI values to acceptable maximum foods must be a conservative estimate. Besides, regional differences in eating habits are obvious obstacles to establishing worldwide standards for permissible levels of food additives.

Since risk is a product of toxicity and exposure, it would be high when the degree and time of exposure are high. Hence, the potential daily intake of a food is of great relevance in considering the ADI of the additives. For example, the ADI of benzoic acid is 5 mg/kg or 300 mg for a 60-kg man. Fruit drinks and beverages, beer, pickles, tomato sauce, minced meat and a number of other foods contribute to one's intake of benzoic acid. In India, our normal dietary habits preclude a high ingestion of tomato sauce and, therefore, the amount of benzoic acid permitted is 450 ppm in tomato sauce. However, in European countries, tomato sauce is used more widely and the benzoic acid levels permitted are lower at 250 ppm.

The ADI can also be related to the caloric content of foods and caloric intakes. Since the highest caloric intake per kg body-weight is 100 cals/day (which is the intake of a one-year-old baby) ADI per kg body-weight can be taken to be equivalent to ADI in mgm for 100 calories. If higher levels of use are required, the additive in question should be either reserved for specific foodstuffs not commonly used or for specific dietary situations. Otherwise, the possibility whether the additive can be replaced by a less toxic substance or whether the same technological effects can be obtained in smaller amounts in combination with other additives should be examined.

K.K.G.M.

fully evaluated so far, and three substances which are prohibited from all foods and flavouring agents. And this is only a beginning.

The Flavour Extract Manufacturers' Association in the USA has prepared a list of substances which are "generally regarded as safe" (GRAS). This list includes all flavouring ingredients used by the industry prior to 1958 and considered by them as safe, based on their common use in food and conditions of use. A scientific literature review of flavouring substances in the GRAS list is being undertaken by the Federation of American Societies for Experimental Biology (FSEB) under contract from the FDA. The FSEB will recommend the priorities to be used in the testing of more than 2,000 flavouring substances and run them through three tiers of test: (1) screening by bacterial or other mutagenic screening systems; (2) those found mutagenic in the initial screening test will undergo a second tier of test involving assays in mice and fruit flies; and (3) those which are inculpated in the first two sets would be subjected to largescale animal testing. This mammoth operation involves taking a toxicological view of more than 400 direct food additives and perhaps up to 10,000 indirect food additives. The concern over the largescale use of various types of food additives has been recently exacerbated by the finding that a number of these additives including flavours and colours caused hyperkinesis (uncontrollable muscle movement) in children.

Yet, many manufacturers are unwilling to disclose the constituents of their flavour extracts, let alone their composition. One of their arguments is that none of these ingredients will be used in high quantities to be of any toxicological hazard because of the self-limiting characteristics of flavour addition in food. However, multiple introduction of some of these additives in several products should be more fully evaluated and a total view taken about the permissibility or otherwise of specific flavouring agents. Among the flavouring agents to be considered with reservation are strawberry aldehyde (ethyl methyl phenyl glycidate) and chloroform. Also, it has been found that many flavouring agents are used in quantities more than 500 ppm in a single food category. These include oils of anise, grape fruit, lemon, lime, orange peel and peppermint, vanilla extract, cinnamaldehyde and methyl salicylate. The National Academy of Sciences/National Research Council in the USA have listed a wide variety of spices, herbs, essential oils, plant extractives and synthetic flavours used in processed foods, for which no formal toxicological data are available. In India, the use of these flavouring materials is limited and there is no serious cause for concern on this account. The WHO/FAO are processing data on ADI and maximum levels of use of commonly used flavouring agents, but it would take at least 10 years to collect data for even the most widely used ones.

The flavour enhancers widely used in the food industry are maltol (ADI 1 mg/kg), ethyl maltol (ADI 2 mg/kg), glutamic acid and its salts (ADI 120 mg/kg, additional to intake from dietary sources) and nucleotides. Monosodium glutamate has been widely used as a flavour enhancer for meat. Recently, some doubts have been raised on the harmlessness of glutamate, based mainly on the work of Olney and Sharpe in the USA who found that subcutaneous injection of monosodium glutamate in newborn monkeys produced lesions in the periventricular region of the hypothalamus of the brain. The "Chinese restaurant syndrome" characterised by a tingling sensation and a flushed feeling due to high ingestion of monosodium glutamate-containing food was also noted. Hence the WHO/FAO's recommendations on ADI for monosodium glutamate do not apply to infants under 12 weeks of age, and the addition of the substance is not allowed in the diet of infants. In any case, babies may be far less sensitive to taste than are adults. In most countries, there is a voluntary ban on the use of glutamate in baby foods as well. Glutamic acid is a normal constituent of all proteins, and the average adult daily consumption of glutamic acid from food proteins is estimated to be of the order of 15 gm. Since the average daily intake of monosodium glutamate is of the order of only 200 mg, it may be stated with reasonable assurance that glutamate as an additive to foods is unlikely to cause any harmful effect. In India, the following levels of acceptance are being considered: glutamate not more than 500 ppm in soups and meat foods for adults; maltol — not more than 325 ppm in biscuits, chocolates and baked foods; and ethyl maltol — a maximum of 600 ppm in biscuits, chocolates and baked foods.

The following solvents in flavours are generally permitted: ethyl alcohol, propylene glycol, glycerol, isopropyl alcohol food grade, acetic acid and propanediol. Solvents such as diethylene glycol monoethyl ether, 1–2 dichloroethane, hexylene glycol, 1–1–2 trichloroethylene and diethyl ether are specifically prohibited.

TABLE II · COLOURS

Natural colours	ADI (mg/kg)	Maximum level permitted	Comments
1. Caramel			
Non-ammonia process	Not limited	Limited by GMP*	
Ammonia process	100 (temporary)		4-methyl imidazole not to exceed 200 mg/kg
2. Annatte	1·25 (temporary) (as Bixin)	300 mg/kg	
3. Carotenoids	5	Limited by GMP	
4. Chlorophyll	15	Limited by GMP	
5. Turmeric	2·5 (temporary)	Limited by GMP	On the basis of 3% curcumin in turmeric
Curcumin	0·1 (temporary)		
6. Riboflavin	0·5	Limited by GMP	
7. Saffron	na**	na**	

* Good manufacturing practice ** Not available

Synthetic colours	Common name	ADI (mg/kg)	Maximum level permitted	Comments
1. Red	Ponceau 4 R (Food Red 7)	0·75 (temporary)	30–300 mg/kg in different foods	
	Carmoisine (Azorubine)	0·5 (temporary)		
	Amaranth	0·75 (temporary)	30–200 mg/kg in different foods	
	Erythrosine	1·25 (temporary)	30–300 mg/kg in different foods	With a 0·1% limit of fluoroscein
2. Yellow	Tartrazine	7·5	30–200 mg/kg in different foods	
	Sunset Yellow FCF	5	30–200 mg/kg in different foods	
3. Blue	Indigo carmine (Indigotine)	2·5 (temporary)	200 mg/kg	
	Brilliant Blue FCF	12·5	100–200 mg/kg in different foods	
4. Green	Green S	5 (temporary)	100–200 mg/kg in different foods	
	Fast Green FCF	12·5	200 mg/kg	

REGULATIONS

In India, food additives come under the provisions of the Prevention of Food Adulteration Act, 1954 (Act No. 37 of 1954). It comes under the purview of the Health Ministry. A committee, called the Central Committee for Food Standards advises the Central and State governments on matters relating to the setting up of standards and the administration of this Act. It also carries out other functions assigned to it under this Act.

In the USA, the Federal Food and Drug Administration is the authority responsible for ensuring the safety of food additives. It sets the necessary specification for the product and, in most cases, establishes specific tolerances. In the UK, the Ministry of Agriculture, Fisheries and Food and the Ministry of Health are jointly responsible under powers conferred on them under the Food and Drugs Act, 1955.

In the UK, the British Industrial Biological Research Organisation at Carshalton, Surrey, evaluates all food additives used by industries and also provides information on the current development in food additives legislation in various countries. There is a need in India for a similar organisation to review and canalise work in this area and provide information to all industries and various departments of the Government. There is also a need to study and evaluate several of the additives commonly used in India. At the moment, not much research work is being done in food additives and the standards are taken from studies done abroad. K.K.G.M.

A number of *nutrient supplements* such as various vitamins, amino acids, minerals and essential fatty acids are also permitted in judicious amounts in most foods. Many manufacturers of ready-to-eat breakfast foods add thiamine, riboflavin, niacin and iron on a voluntary basis. These are meant to produce products containing nutrients in quantities corresponding to those in the cereals from which the foods are made. Also, vitamin A is usually added to vanaspati and margarine, potassium iodide or iodate in common salt and vitamin D in certain milk products. Many calcium and iron salts are added as mineral supplements in a number of food formulations. Lysine is used to fortify bread and cereal mixes and many trace elements like zinc, copper, cobalt, molybdenum, etc are added in some mineral mixes in human and animal nutrition.

Of the non-nutritive *sweeteners*, saccharin is the most widely used, with an ADI of 5 mg/kg for common use and up to 15 mg/kg for dietary purposes for diabetics. Permission for the use of cyclamate has been withdrawn. Sorbitol is allowed as a non-nutritive sweetener in foods, the maximum permissible levels being limited by good manufacturing practice.

Though the use of cyclamate has been banned, earlier fears about the carcinogenic potential of cyclamate has been shown to be groundless. Both cyclamate and cyclohexylamine gave negative results in the new Ames test for mutagenicity. This supports the view that they are non-carcinogenic: there is no justification, therefore, to classify cyclamates as carcinogens. However, there are other genetic questions raised by cyclamates, including Down's syndrome and testicular and reproductive results in test animals which establish a cyclamate tolerance too low to permit the use of this material as an artificial sweetening agent. Saccharin, unlike cyclamate, is not metabolised either in experimental animals or in man, but is excreted unchanged. There have been no serious challenges to its use on toxicological grounds. However, there is a limit of 100 ppm on the amount of orthotoluene sulphonamide (OTS) in saccharin.

Recent Canadian studies have shown that saccharin "can produce malignant bladder tumour in rats" and the Department of Health and Welfare in Canada has banned its use in foods on the basis of these results. But, OTS, an impurity in saccharin, which had previously been incriminated as a carcinogenic factor, was shown to be non-carcinogenic in these Canadian tests. The FDA in the USA has taken legal procedures necessary to issue a total ban on the use of saccharin in foods citing Canadian "definitive" data indicting saccharin as a potential carcinogen. However, no similar action has been taken in the UK and in other European countries.

There has been a chorus of attack on the FDA on the ban on saccharin since Americans consume over 3 million kg of saccharin every year and millions of people use it in dietetic foods, especially for the control of diabetes and obesity. To complicate matters, pure saccharin is not mutagenic in the Ames test (a sensitive in vitro test for screening cancer-producing substances). Further, many scientists point out that when it comes to bladders, rats are a special breed, which concentrate their urine to a very high specific gravity. This means that the chemicals in the urine are apt to remain in the bladder for comparatively long periods before being excreted. Suggestions have been made, therefore, that saccharin should be tested in other species.

The FDA in the USA may insist on the enforcement of a ban on saccharin in foods but may re-classify it as an over the counter (OTC) drug on the basis that it is efficacious for medicinal purposes. However, the ban on saccharin has given an impetus to the search for alternative sweeteners. These include: (*i*) talin, a substance about 2,000 times as sweet as sucrose, produced from the seeds of the fruit of *Thaumatococcus daniellii*, which grows wild in West Africa; (*ii*) xylitol, a naturally occurring sugar with about the same sweetness as sucrose; (*iii*) aspartame, a dipeptide sweetener; (*iv*) acetosulpham, a substance 250 times sweeter than sucrose; (*v*) cyclamates, which were at one time used as sweetening agents and were later banned (further evidence for its biological safety is being considered by the FDA); and (*vi*) dihydrochalcones, prepared from grape fruit and orange rinds, which have been shown to have lingering sweetness.

Anticaking agents are added either in the processing or in the manufacture of foods to produce effects like free flow or freedom from caking. The substances added include carbonates or phosphates of calcium or magnesium, silicates of calcium, magnesium, aluminium or sodium, silicon dioxide, myristate, palmitate or stearates of aluminium, ammonium, calcium, magnesium, potassium or sodium. These are added only when they are deemed absolutely essential.

An international appraisal of food laws pertaining to additives is essential for continued public health protection and understanding and anticipation of problems of import and export of foods. Regulations in this area have always come out easier against something, rather than for something. But there are no two opinions on the beneficial role of food additives in enabling man to extend and vary the quantum and kind of food available and make it more presentable and acceptable.

Dr. Menon heads the Hindustan Lever research group in Bombay. He is on the Central Committee for Food Standards, and is also associated with several committees of the Indian Standards Institution and with dairy research in India.

Recommends reading: **1.** Furia, T. E. (ed) 1972 *Handbook of Food Additives* (2nd ed) CRC Press, Ohio, USA. **2.** National Research Council, USA, 1965 *Chemicals Used in Food Processing*, Publication 1274, Washington DC. **3.** Council of Europe 1973 *Natural Flavouring Substances, their Sources and Added Artificial Flavouring Substances*, Strasbourg. **4.** Sanders, H. J. 1966 Food additives *Chem. & Eng. News* (Oct. 10 and Oct. 17). **5.** Menon, K. K. G. 1972 Problems of Food Additives and Contaminants *Proceedings of the First Asian Congress of Nutrition* Nutrition Society of India, National Institute of Nutrition, Hyderabad. **6.** Govt. of India *Prevention of Food Adulteration Act and Rules* Ram Narain Lal Beni Prasad, Law Publisher, Allahabad.

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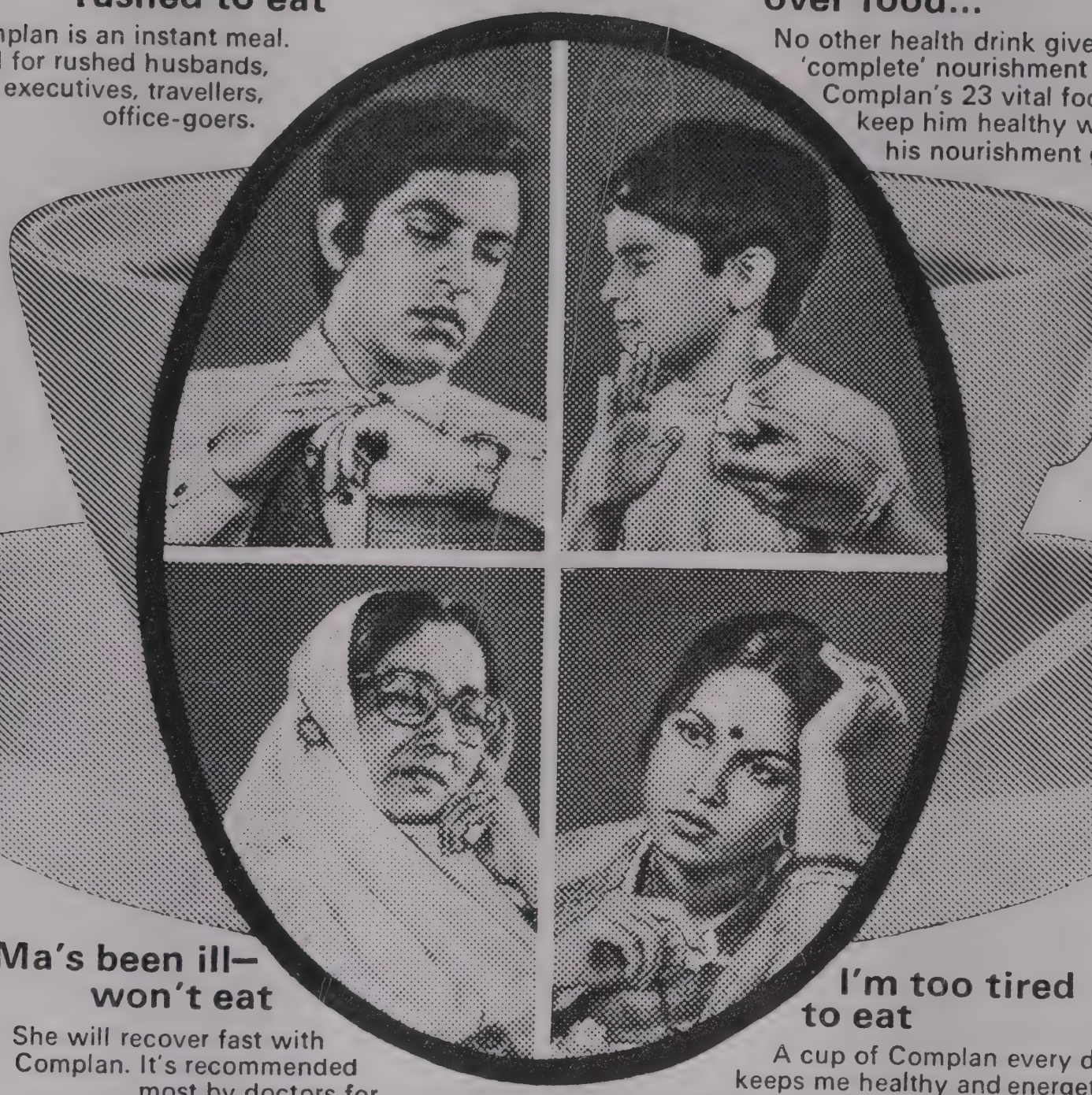

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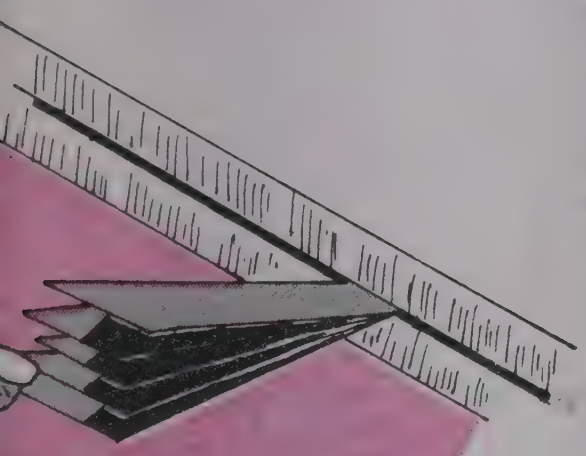


Fig. 1

It used to be a rather common scene in the old Western movies: Red Indian scouts would fall to their knees and press their ears to the ground to detect the hoofbeats of distant, unseen riders. Now, why couldn't they hear the hoofbeats through the air? After all air is the medium through which sound vibrations are carried to the listener. Well, before we answer the puzzle, let's take a look at the phenomenon of sound.

When a body vibrates, it produces vibrations in the air column around it and produces sound. Stick a razor blade into a slit at the side of a table. Strike the free end. As the blade vibrates, you can hear a buzzing sound. Sound propagates in the form of waves and these waves travel in all directions like water waves when a stone is dropped in still water. Sound waves travel through the medium of air and reach our ears.

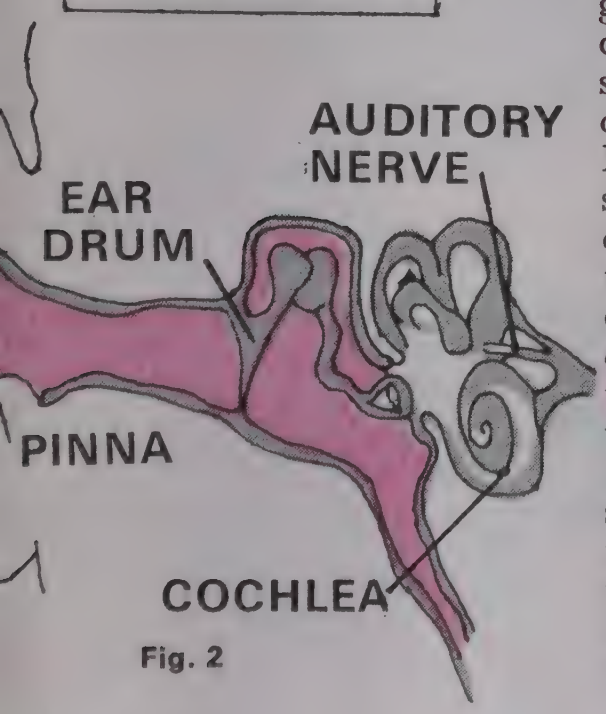
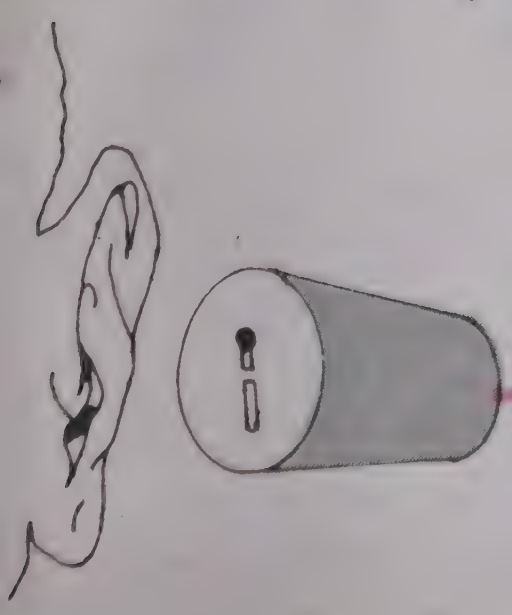


Fig. 2

The human ear is one of the greatest wonders of nature. It can detect and differentiate between sounds within an enormous range of frequency (from 20 to 20,000 Hertzs, or cycles per sound). The sound waves are collected at the outer ear called *pinna* and carried through the channel to the ear drum and set it vibrating. The ear drum transmits the vibrations to the inner ear called *cochlea*, through a chain of three bones. In the cochlea, nerve endings are stimulated and carry messages to the brain indicating the rate of vibration in the inner ear and we thus hear a note of appropriate pitch.

But, then, while sound waves are principally vibrations in the air, they can also be vibrations in water, wood, metals, and the ground, too. Actually, sound waves are conducted more readily through these things than through the air. So, now we have the answer to the puzzle why the Red Indian scout would put his ear to the ground to hear the distant rider!



How about some practical demonstrations? Place your ear tightly on to a table and ask somebody to tap on the table some distance away with a spoon. The sound would reach your ear like a loud 'bang'; through air, it would be carried to your ear merely as a 'tap'. Try another experiment: hold a wrist watch tightly between your teeth and close both ears tightly with the palms of your hands. You can now hear the ticking much more loudly.

Even a string will transmit sound vibrations much better than air. Tie a spoon at the middle of a metre-long string and hold both ends of the string tightly to your ears (Fig. 3); bend forward a little so that the spoon hangs freely. Ask a friend to beat the spoon with another one. The sound will reach your ears like the 'gong' of church bells!

Fig. 3

Now you can understand how toy 'string telephones' work. Let's make one. It's very simple really. We need two empty tins and several metres of thin string. Punch a hole at the bottom of each tin, pass one end of the string through and tie it with a matchstick. Ask your friend to pull the string taut and speak into his tin. Hold your tin to your ear and you can hear him quite distinctly (Fig. 4).

Fig. 4

PROBLEM

Does the pitch heard in the receiving can depend on the tightness and density of the string, and the size of the can?

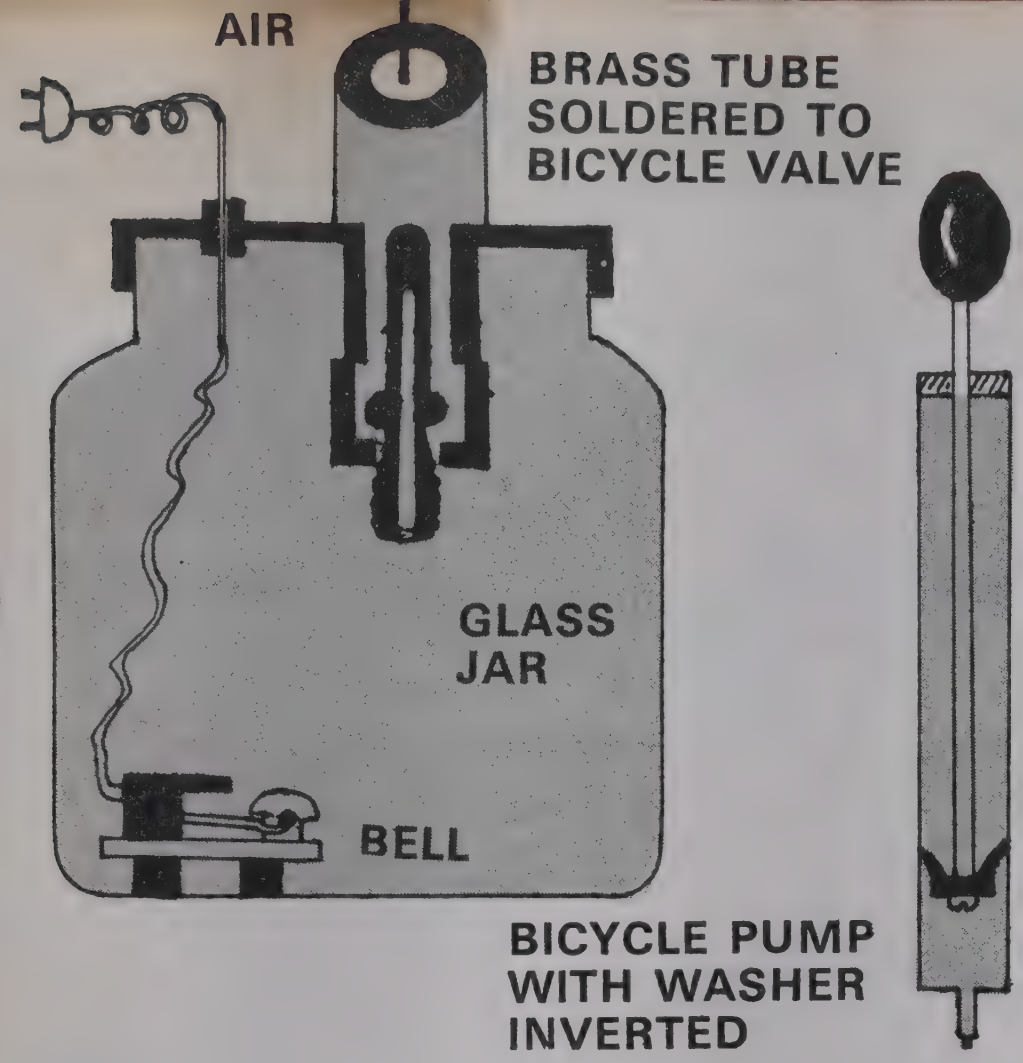


Fig. 5

Fig. 5 shows an experiment that proves the most important property of sound. Let's get an electric bell, a glass jar with air-tight lid and a vacuum pump. (You can use a bicycle pump by inverting the washer inside.) Place the bell inside the jar and take the wires out through the lid. Take a bicycle tube valve unit and fix it on the lid in downward direction. Switch on the bell and you can hear it ringing. Now, slowly take out the air inside the jar by using the pump. The ringing sound becomes fainter as you go on creating vacuum in the jar. When, there's no more air left in the jar, you will hear no ringing. Why does it happen?

We have seen that sound requires a medium through which to travel to reach our ears. How about proving the waves are transferred onwards in all directions? We shall need a tuning fork (Fig. 6a) for that. Since it is difficult to come by a professionally made tuning fork, we can make one from a mild steel bar (1 cm square, or 1 cm diameter if rounded) (Fig. 6b). Hang a table-tennis ball from a string. Hold the fork lightly and then hit it against wood. The fork will produce sound. Now, if you bring the fork close to the ball, you'll find the ball, too, vibrates!

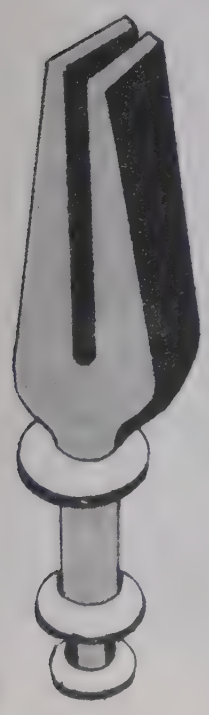
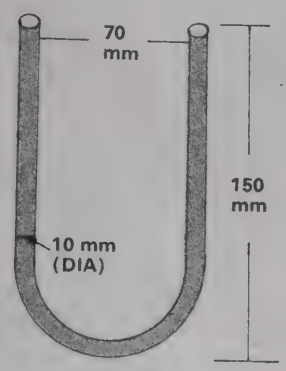


Fig. 6a The tuning fork. The instrument, which when struck gives a note of accurate pitch, was invented by John Shore, a trumpeter at the Chapel Royal in London, in 1711

Fig. 6b



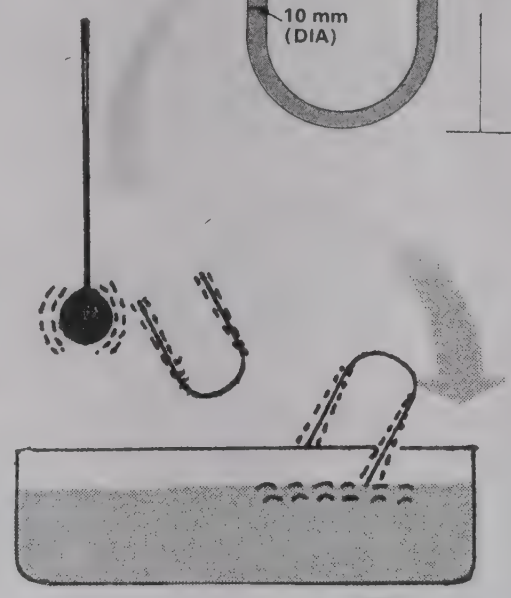


Fig. 7

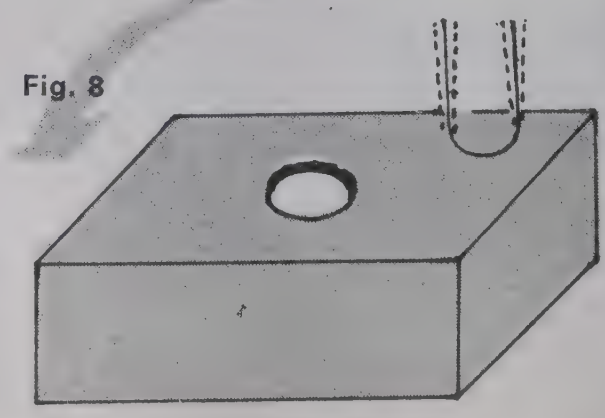


Fig. 8

Again, if you take a tub with water and dip the vibrating (after impact) fork, waves will appear on the water's surface (Fig. 7). And, then, a vibrating body will produce more sound if it comes into contact with another body of larger surface. Hold the tuning fork (after impacting) on a hollow box closed on all sides except for a hole at the top (Fig. 8). How does the sound come out?

How often have you held a rubber band between your teeth, stretched it and played on it? Must be many, many times. But, how often did you notice the difference in the pitch of the 'twang' sound depending on how far you stretched the band?

Fix a nail at one end of a wooden board (60 cm × 15 cm × 1 cm size) and tie a metre-long steel wire to it. Place a wedge near this nail and at the other end of the board, place a wooden cylinder between four nails. Take the wire over the wedge and the cylinder and hang a weight at its free end (Fig. 9). Play the steel wire with your finger. Repeat the experiment with different weights (that is, different degrees of tautness) and different lengths of wire (that is, by moving the wedge). You will notice a higher note comes out as you increase the tautness or reduce the length of the wire.

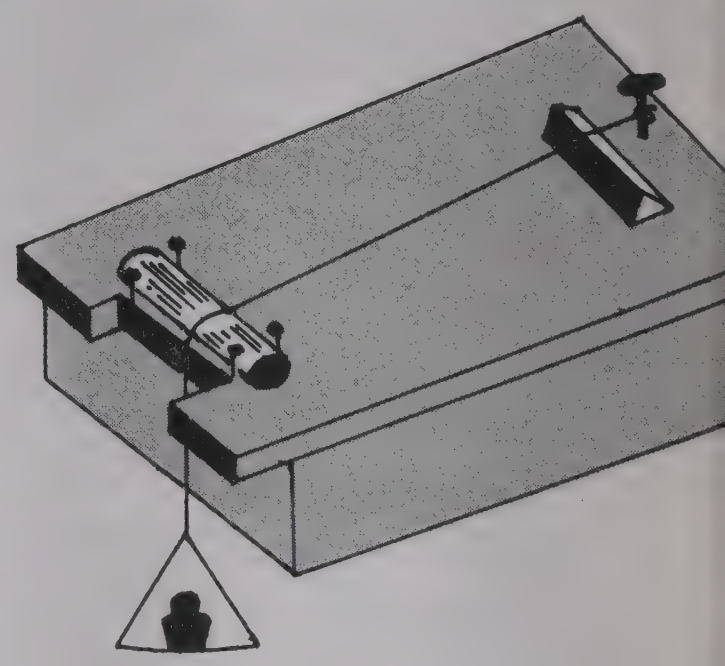


Fig. 9

Resonance

If you know somebody who has a pair of violins, ask him or her to set their wires to tune identically. Place the violins side by side. Now strike the wires of one violin; the wires of the other will start vibrating. How does it happen?

g. 10

The answer lies in ' resonance '. Every vibrating object has its own natural frequency of vibration. If sound waves having the same frequency are allowed to act upon it, it will vibrate in sympathy with the sound waves. This is known as resonance. We can demonstrate this with two identical tuning forks (Fig. 10). Fix the tuning forks each in a hollow box and then place the boxes side by side. Hit one tuning fork with a rubber hammer, allow it to vibrate for a moment and then stop it by touching the prongs with your fingers. The other fork will be found vibrating due to its resonating frequency.

Figs. 11, 12 and 13 show how to make some musical toys — a toy-violin, a ding-dong bell (like a Japanese wind-chime), and a xylophone!

TOY VIOLIN

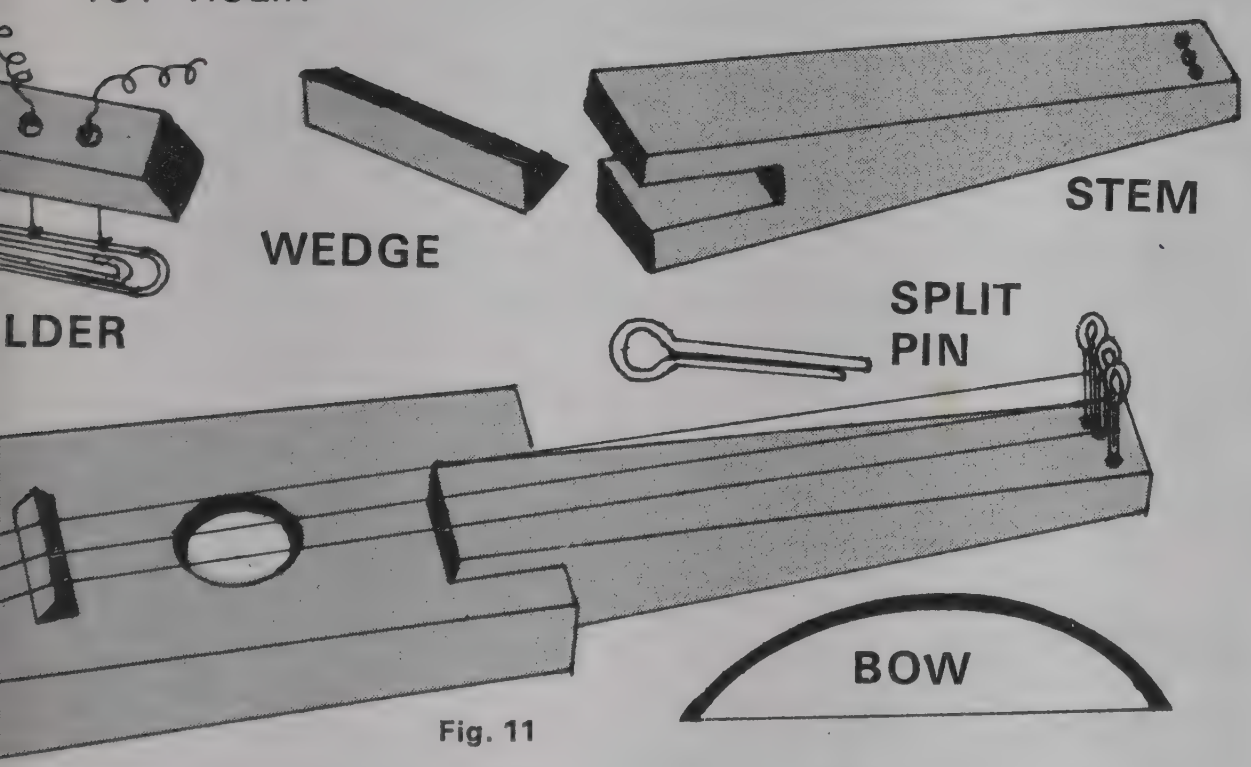


Fig. 11

We need a cigar box, two wooden ieces, a wooden batten, regular usical strings, bamboo-stick (20 cm ng) horsehair and three split ins. Cut a slot in the batten and x it on to the cigar box (using a rong adhesive). Cut a 2·5 cm iameter circular hole in the box. t the other end of the batten drill ome holes for the split pins. Take a mall rectangular piece of wood, rill three holes for wires to pass hrough and screw it on to the ther end of the cigar box. Pass the strings through the holes and secure by tying knots or winding the ends on a paper clip. Tighten the strings by means of the split pins. Take a triangular piece of wood (1 cm × 1 cm × 4 cm) to make the bridge (wedge).

Bend the bamboo stick and tie with horsehair to make a bow. You can tighten or loosen the strings by turning the split pins.

If you are musical and have the aptitude, you might even be able to play some tunes on it.

DING-DONG BELL

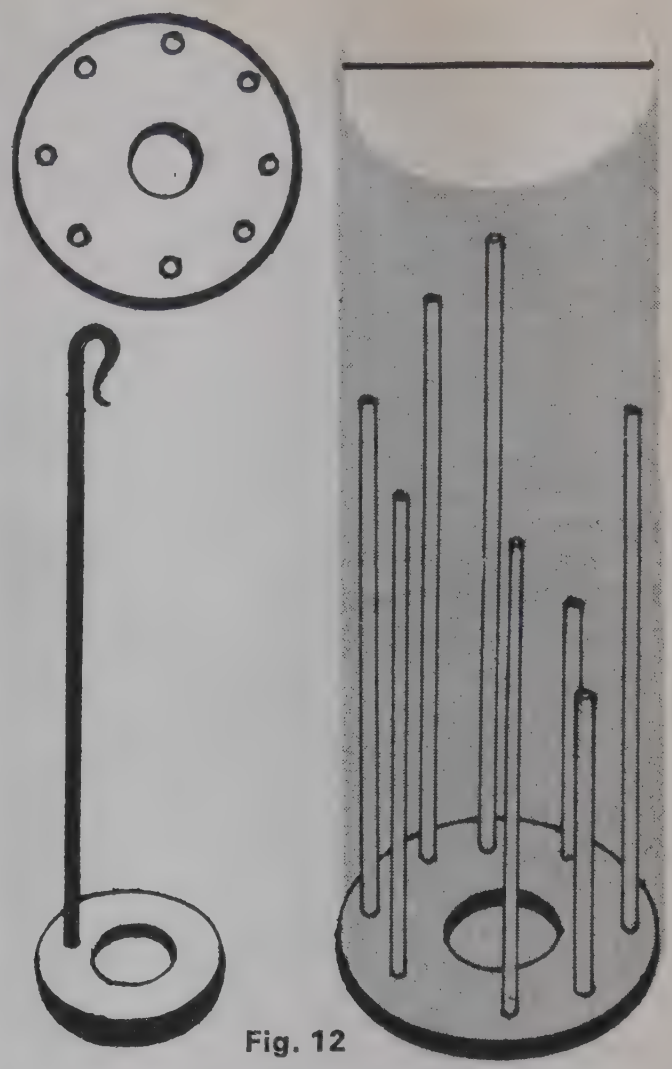


Fig. 12

We shall need a thick metal washer (5 cm dia and 5 mm thick) and hard steel wire (1·5 mm dia). From the steel wire, cut eight pieces of 4 cm to 11 cm length (each longer by 1 cm). Drill eight holes of 1·5 mm diameter near the outer edge of the washer. (You may have to make use of workshop machinery for this toy.)

Fix the wire pieces tightly in the holes. Now prepare a cardboard cylinder (about 13 cm long) with the bottom closed and place the washer (with the standing wires) at the bottom. Now we need a beating hammer. Take another washer of 2 cm diameter and drill a 15 mm hole in it. Fix a wire length (10 cm long) into it and turn the other end into a hook and hang it from soft wire from the open end of the cylinder.

Hold the cylinder and tilt it in different directions ; as the 'beating hammer' strikes the different wires, you can hear the sound of different musical notes.

XYLOPHONE

You can use either wooden strips 2 cm wide and 1 cm thick) or ild steel flat (3 cm wide and 2 cm ick). Cut eight pieces of 8 cm to 5 cm long, with increments of cm. Drill 3 mm-diameter holes at oth ends of each strip. Take two attens (4 cm × 1 cm × 25 cm), lay trips of felt or satin cloth on them nd place the strips by driving nails hrough the holes to hold them *oosely.*

Prepare two wooden strikers. As ou tap the strips with them, you ave a rather sweet-sounding xylo-hone.

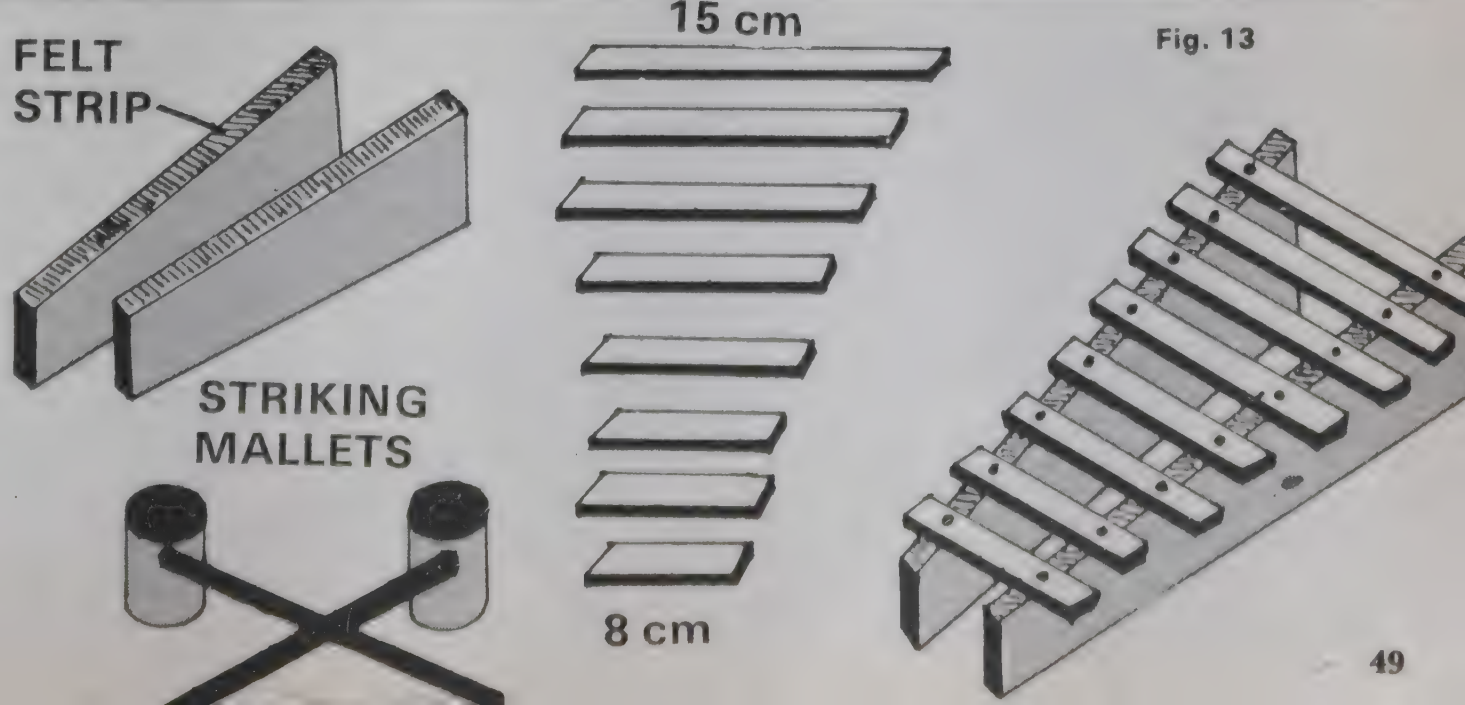
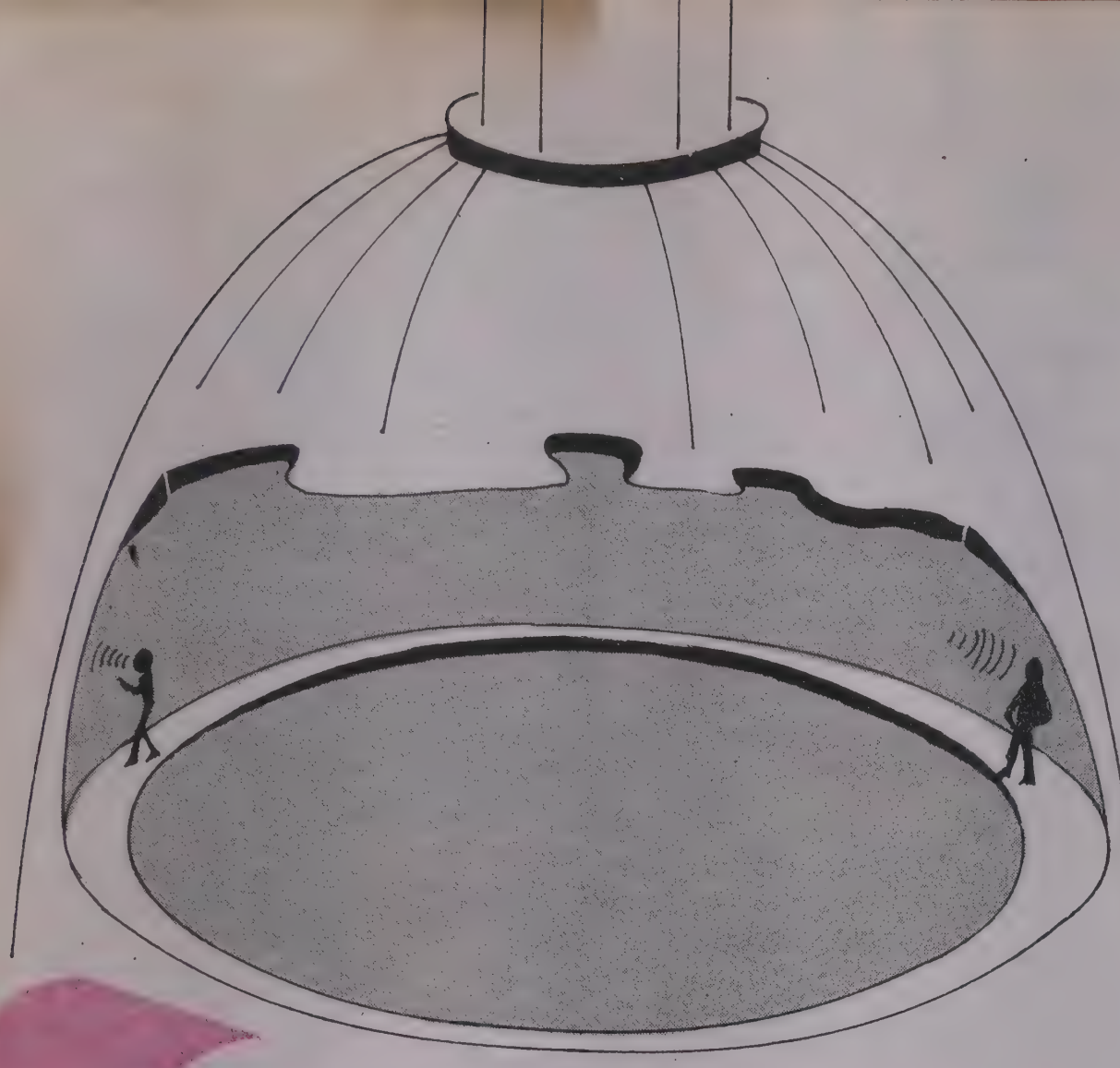


Fig. 13



Whispering galleries

Some rooms are noted for their strange acoustics; some even provide a focusing of the sound. It's said, the dungeons of Syracuse were built in such a way that the jailors could hear every conversation and even whispers of the prisoners; it was called the "Ear of Dionysus". The story goes, the dome of the old Hall of Representatives in the Capitol building at the US capital had a similar reflecting capacity; even a whisper from one side of the chamber would be heard on the other side and had embarrassed many a member on more than one occasion.

In the dome of London's St. Paul's Cathedral, there is a "whispering gallery" If somebody whispers *to the wall* anywhere in the gallery, one can hear the whisper no matter where one is standing along the gallery. And, strangely, the more the whisperer faces the wall and is closer to it, the better the sound reproduction. Is this just a matter of reflection and sound focusing? The British physicist Rayleigh had built a model of the gallery to find out why it occurs. At one end he placed a 'bird-call' whistle and at the other end, a candle. When sound waves from the bird-call reached the candle, the flame flickered. So there was the answer, wasn't it? It wasn't so simple really. When Rayleigh inserted a screen at some intermediate point (see Fig. 14), the flame didn't flicker. Why not? After all, the screen was placed along the perimeter, far out of the direct path of the sound wave to the candle! Well, Rayleigh did

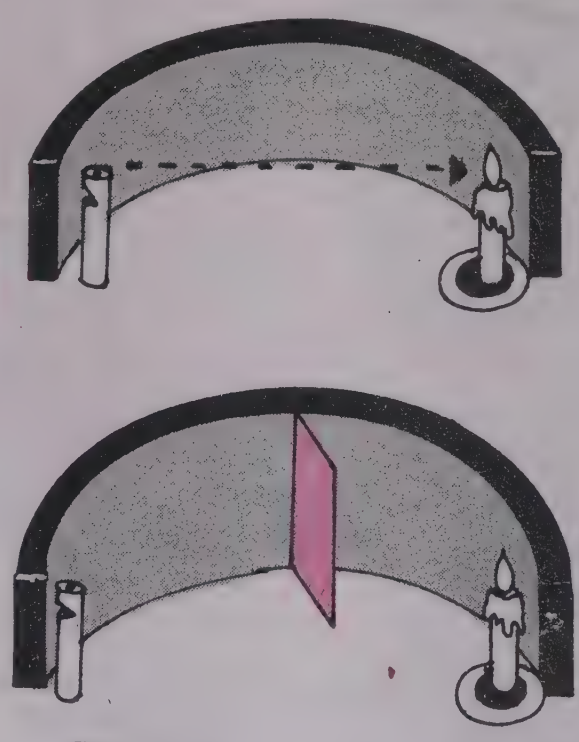


Fig. 14

find his answer and, hence, a clue to the nature of a whispering gallery. Can you work it out?

In Bijapur in Karnataka, there's a building named "Gol Gummat" with a 33 metre diameter dome roof. If you stand in the gallery and shout, you will hear the same sound repeated seven or eight times. In other words, you hear 'echoes'.

Echoes are reflected sound waves. Stand some distance away from a building and facing the wall, give a shout. You hear a similar shout coming from the wall. Now, we know the speed of sound waves: they travel through air at 330 metres per second. So, if you can time the echo of your shout, you can calculate the distance to the wall. When you see lightning, count the seconds before you hear thunder. You can then tell how far the lightning was by multiplying 330 m by the number of seconds taken to hear the thunder!

Echoes are reflected sound waves. When multiple reflections occur, they are called reverberations. Take a hollow cylindrical paper roll, 5 to 6 cm in diameter, and about one metre long. Ask somebody to speak at one end as you hold your ear close to the other end. You will not be able to hear a clear speech but warbles with multiple reflections of sound waves (Fig. 15). This phenomenon of reverberation is generally experienced in large audi-

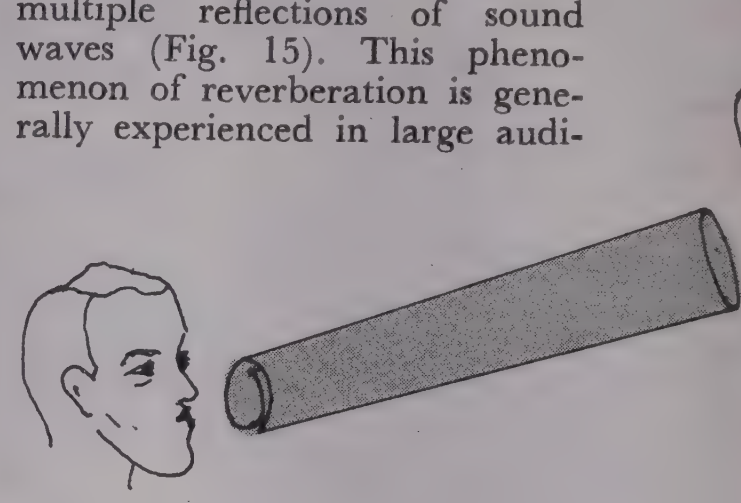
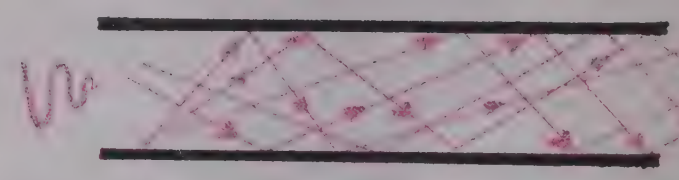


Fig. 15



SOUND WAVI

toriums and under bridge arches.

In fact, the phenomenon of sound is so intricate that we cannot hope to cover all its aspects in this very elementary discussion. For instance, there is the 'Doppler effect'. If you stand on a railway platform and carefully listen to the whistle of a fast approaching train, you will feel the sound of the whistle is a little loud as the train approaches, but it is lowered immediately after the engine passes you. When the source of sound, or the listener (or both), is moving towards the other, the listener will encounter the sound (from the source) a little faster than if both were stationary. The apparent frequency is increased and hence the listener

hears a pitch slightly higher than the pitch emitted by the source.

Let's end this discussion on sound with a small poser: if you have ever recorded your own voice on a tape recorder, why is it that your voice on the tape *always* sounds a little different from what it sounds to you normally?

●●

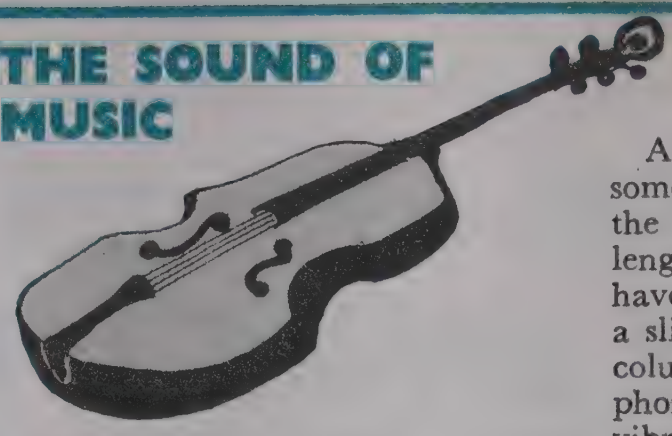
SOUND REPRODUCER

Here's a crude toy 'record player' hat you can make. Take an empty hatch box and remove the inner ontainer. Cut out the base and fix thin tracing paper on it. Take a n foil and bend it so that it touches he diaphragm as well as a needle xed into a side of the container. ut a small circular hole in the outer hatch box cover. Insert the con- ainer into the box.

Now prepare a record player using wo wooden discs of 20 cm and 5 cm iameters, respectively (and 1·5 cm hick). Cut grooves on their edges or holding the cord to drive the ulleys. An additional pulley may e used to keep the cord taut.

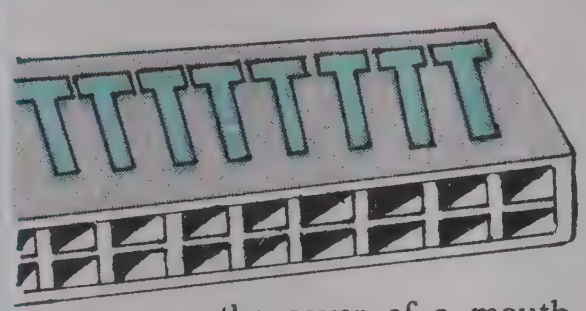
Rotate the disc by a handle and he record disc will rotate. Get an ld, thrown-away record (it's better ot to use a good one), place it on he turn-table and gently hold the ick-up on the record. You can hear he music! (An alternate pick-up made by rolling paper into a cone is also shown in the diagram.)

THE SOUND OF MUSIC

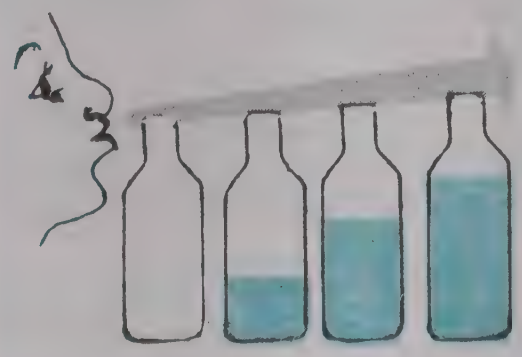


If you look at a violin or cello closely, you will notice the strings that produce low notes are thicker than those producing high notes. Also, the higher-note strings are pulled more taut. Instrumentalists use their fingers to make the strings 'shorter' (and produce a higher note). Pianos and harps have a string for each note: the strings for the low notes are long, thick and kept less taut; those for the high notes are short, thin and tight.

What about wind instruments? If

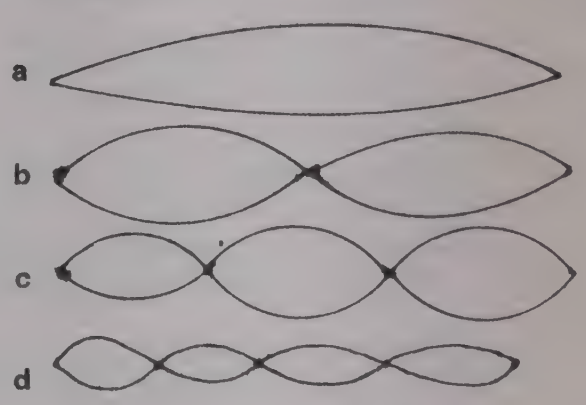


you remove the cover of a mouth-organ, you can see strips of metal, called reeds, that vibrate to produce sound as air is forced past them. The longest reeds are the easiest to blow and give the lowest notes. In some instruments, sounds are produced by vibrating air columns. Blow over an empty bottle. Add some water to the bottle and blow again. Repeat with varying water levels. Each time water is added, the column of vibrating air becomes shorter and the pitch of the note is higher.



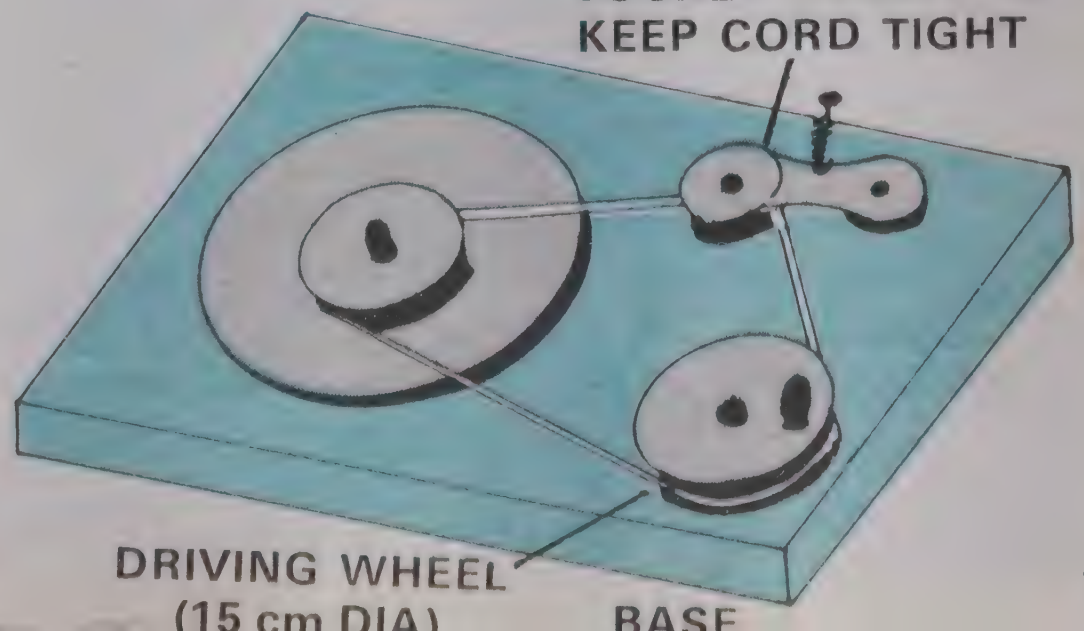
All vibrating air instruments have some means of varying the length of the air column. In organs, it is the length of the pipes. Bugles and horns have coiled tubes and trombones have a slide to vary the length of the air column. Though clarinets and saxophones have a reed to start the air vibrating, the note they produce depends on the length of the column of vibrating air.

In fact, the quality of musical sounds depends not on the 'purity' of the sound but rather on the overtones or 'harmonics' that impinge on the main or 'fundamental' notes. If a thin wire is stretched along the top of a box and then plucked, it can be seen vibrating along its entire length (Fig. a). If we touch it lightly at the midpoint it will vibrate in half-lengths and the frequency of vibrations will be doubled (Fig. b). Similarly, it is possible to make the wire vibrate in sections of a third (Fig. c) or a quarter (Fig. d) of its length, producing sound waves with three or four times the original frequency. In each instance, the note sounded is a 'harmonic' of the original or fundamental note.



PROBLEM

It is known that some opera singers can actually shatter wine glasses when they sing at a particular high pitch. Why does the glass shatter? And why does it take several seconds before the shattering takes place?



Optimisation techniques

OPTIMIZATION TECHNIQUES FOR CHEMICAL ENGINEERS by Asghar Husain & Kota Gangiah, The MacMillan Company of India Ltd, 1976, 317 pp, Rs. 18

The authors have done a commendable job in presenting an optimal blend of the theoretical and computational aspects of various optimisation techniques of direct interest to chemical engineers. Though the book, in its present form, can serve as a text-book for an advanced undergraduate or post-graduate course, modifications in the introductory chapter and the chapter on constrained optima would enhance its value.

In the introductory chapter, the authors, after defining optimisation and briefly outlining its scope, present not only the basic terminology but also a number of important terms like stationary point, saddle point, Lagrange multiplier, etc. These terms could have been introduced with greater effect at appropriate points in the text. The structure and classification of optimisation problems should have been formally presented.

Unconstrained single variable and multivariable search procedures have been discussed very well in the second and third chapters. The computational aspects of most of the important methods have been clearly explained. The theoretical basis of the variable metric method could have been developed in greater detail at the expense of transformational discrimination. Necessary and sufficient conditions of unconstrained optima should have been outlined at the beginning.

The chapter on constrained optima is presented in too brief a manner. The concepts of Lagrange multipliers and constrained derivatives have been well developed. In the section on inequality constraints, the basis of Penalty Function approach could have been more fully explained with the dual problem. The condenser design problem which follows illustrates only the formulation aspect. The treatment of linear programming is inadequate. The basic properties of LP problems could have been presented in place of the refinery blending problem which emphasises only the formulation aspect. The development of geometric programming is also inadequate. A very useful search procedure like the complex box finds no place in the book. Dynamic programming has been presented skilfully with adequate examples to give the reader a clear idea of the principle of optimality.

The last two chapters are the highlights of the book. The chapter on variational methods presents a concise and lucid exposition of calculus of variations and weak and strong versions of Pontryagin's principle. The computational features as well as the merits and demerits of various methods for solution of TPBV problems have been well illustrated with adequate numerical results. The last chapter on difference method for time domain is significant in the sense that it presents an original contribution of the authors on dynamic optimisation of free terminal time problem. The basis of the method and its computational aspects have been clearly brought out with numerous examples.

K. P. MADHAVAN

[Dr. Madhavan is Assistant Professor in the Department of Chemical Engineering, Indian Institute of Technology, Bombay.]

Breaking the Brahminical barrier?

THE PENGUIN DICTIONARY OF PHYSICS, edited by Valerie H. Pitt, Penguin Books, England, 1977, 428 pp, £2 (Rs. 32)

In these days of pocket calculators, microwave ovens, and satellite television, an increasing quantum of technical jargon elbows its way into the consciousness of modern man. There it sits, familiar, but for the most part impenetrable, like one's neighbours in a city apartment complex.

For readers of science magazines, the problem is more acute since much of modern science is communicated in Brahminical terminology carefully selected for its opacity and proof against leakage outside the caste. Recent trends in modern physics to adopt the lucrative nomenclature of Madison Avenue have not improved the situation — the "charm" of an elementary particle is no more comprehensible to the intelligent layman than its "isotopic spin". The language dictionaries do not usually carry explanations of words like "metal oxide semiconductors"—and this is where a technical dictionary should come in to fill the gap.

A technical dictionary should be reasonably *complete*, and it should be *comprehensible* to its intended audience. How well does the *Penguin Dictionary of Physics* fulfil these criteria? I tested the first by choosing at random 12 words from my physics vocabulary and looking them up. The dictionary carried the meanings of eight of these, including technical terms like Zener diodes, and Schwarzschild radius, but it missed out on important concepts like that of a physical 'state', a 'boundary value problem' and even with 'amorphous semiconductor'.

As for the second criterion, according to the preface, the book is intended for an audience of "students and teachers of physics, doctors, scientists, technologists. . . ." Is it likely to be very useful to the average reader of a magazine like SCIENCE TODAY? I don't think so. Most of the explanations are given in a language as technical as the words it seeks to explain. The only audience that it is likely to serve well is one which is already quite familiar with the subjects, but may have forgotten some details — that is, working physicists, etc.

Booksellers inform us that it is customary to price a book keeping in mind the expected rate of inflation in the period subsequent to its issue. At £2, the publishers of this paperback don't seem to have much faith in the future of the British economy.

VIVEK MONTEIRO

On Group Theory

ELEMENTS OF GROUP THEORY FOR PHYSICISTS by A. W. Joshi (2nd edition), Wiley Eastern Limited, New Delhi, 1977, xiii+324 pp, Rs. 45

The book, written at the MSc degree level of Indian universities, was first published in 1973. That a second edition has been brought out within four years speaks highly of the book. I found the book very good; it is eminently suited to the requirements of Indian students. The major feature that recommends this book, compared to most Western books on this subject, is its explicitness — this should be seen in the context that most students often have to study on their own.

(*Contd. on p. 61*)

What is a 'neutron bomb'?

A recent news item that had created a lot of stir was about the test conducted in the USA of a new nuclear warhead designed to kill living beings with intense radiation while causing a minimum of blast damage to buildings and equipment. This warhead, which could be placed on missiles, has been called by some as the 'neutron bomb'. What makes it different from the existing nuclear warheads?

The device is likely to consist of an intense source of neutrons generated by a triggered nuclear reaction of a kind which is already well-known in physics. The secret, probably, lies in the technique of initiating a proper nuclear reaction in which high energy neutrons are generated. Let us first examine a few of the most important neutron-generating reactions.

One of the most important present-day neutron sources is the well-known fission reaction. When the nucleus of one of the heaviest elements undergoes fission, it splits up into two smaller nuclei and the nuclear reaction energy is shared between the two fragments in the form of kinetic energy and they begin to move apart. These nuclei, in addition to their kinetic energy, have large excitation energy. They lose their *excitation energy* by emission of *neutrons* and gamma rays of various energies. The unstable nuclear fragments undergo radioactive decay in which beta particles, neutrinos, X-rays and gamma rays are emitted. The energies of these by-products are not fixed but can vary over a range called the energy spectrum of the reaction. For example, a ^{235}U nucleus, if it captures a neutron, will undergo fission. Among the by-products of this fission reaction will be found, on the average, between two to three neutrons. The average energy of these neutrons is about 1·5 MeV. In the chain-reacting-pile (nuclear fission reactor), these fast neutrons are slowed down (moderated) by elastic collisions with light nuclei and inelastic collisions with heavy nuclei. Slowing down the neutrons enhances the probability that they will be captured by other uranium nuclei, which will then undergo fission, and so on.

In the fission of a ^{235}U nucleus, only a small part of the energy released is carried by the neutrons — only about 5 MeV out of nearly 200 MeV energy released. Of the remaining 195 MeV, nearly 165 MeV is taken up in the kinetic energy of the heavy fission fragments (which is then lost in the surrounding medium causing blast and heat), about 10 MeV in the form of gamma rays, 8 MeV in the electrons released and 12 MeV in the neutrinos. Therefore, in an uncontrolled nuclear fission chain reaction, namely, the nuclear explosion, nearly 85 per cent of the energy released contributes to the blast and heat that damage the surroundings and the remaining 15 per cent appears as fallout radiation, gamma rays and neutrons which are harmful to biological species. The distribution of energy is shown pictorially in Fig. 1a.

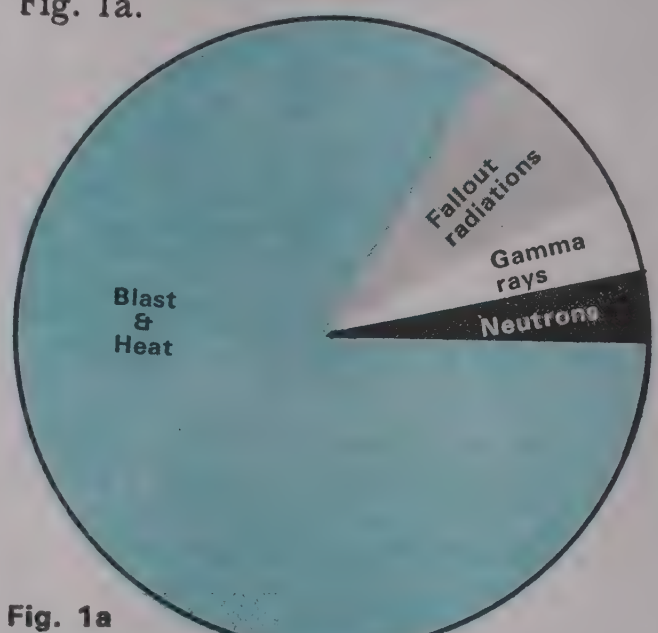


Fig. 1a
Fission energy

The most powerful and versatile sources of neutrons available today are obtained by accelerating charged particles and bombarding a suitable target. Consider the fusion reaction induced by the deuteron (heavy hydrogen) on deuteron which is represented as $^{2}_{1}H + ^{2}_{1}H \rightarrow ^{3}_{2}He + n$ + energy (3·265 MeV). This reaction releases energy and has appreciable neutron yields for low bombarding energies ($\lesssim$ 100 keV). This energy is comparable to very high temperature plasma sources used for thermonuclear reactions in which neutron sources in the range of 10^{14} cm^{-2} sec^{-1} (per square cm per second) are obtained.

Consider the second most important fusion reaction induced by the deuteron on the tritium (heavier hydrogen) nucleus, symbolically represented as $^{3}_{1}H + ^{2}_{1}H \rightarrow ^{4}_{2}He + n$ + energy (+ 17·6 MeV). This reaction is highly energetic, releasing about 17·6 MeV per nuclear fusion. Neutrons of about 14 MeV energy are generated by the low energy deuterons ($\sim$ 100 keV) bombarding the triton target atoms. Since there is a resonance in the reaction yield at $E_d = 100$ keV, the neutron yield will be large enough at this energy. Therefore, if one can create a plasma containing both heavy hydrogen ($^{2}_{1}H = D$) and heavier hydrogen ($\equiv ^{3}_{1}H \equiv T$) at the thermonuclear reaction temperature, fusion will occur, and high energy (14 MeV) neutrons can be generated.

Note that most of the energy released in thermonuclear fusion reactions described above is in the kinetic energy of the neutrons (Fig. 1b). Thus, fusion reactions are neutron-rich while fission reactions are energy-rich.

In this context, the announcement of a break-through in the production of neutron bomb means that it has been possible to produce a neutron-rich explosion minimising the blast

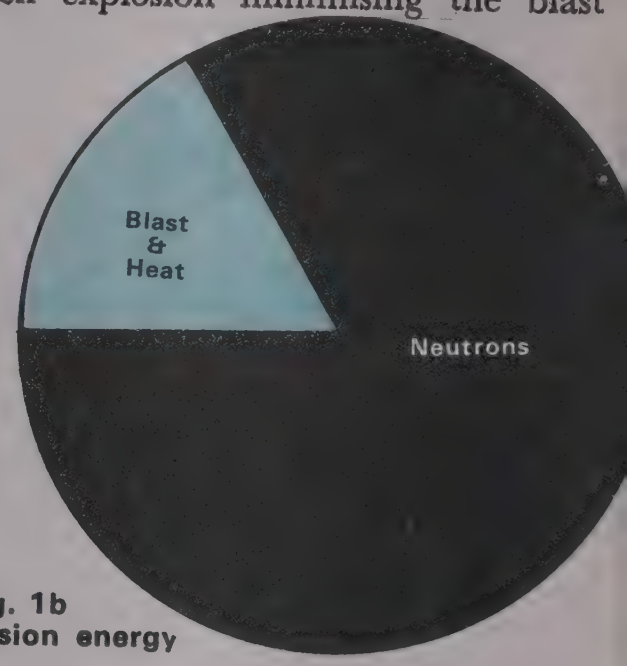


Fig. 1b
Fusion energy

energy that is associated with the bomb. In the ordinary fusion bomb — for example, a hydrogen bomb — the trigger is usually a fission device, which itself produces enormous blast energy in addition to energy produced in the fusion reactions. In a neutron bomb, obviously, there does not seem to be a fission trigger, thus minimising the blast energy produced and enhancing the number of neutrons produced per unit of explosive energy. It is conceivable such a device could have been built on the basis of very secret technological developments in the area of high-density pulsed plasmas. It is not yet clear what the technical method is.

The description of the neutron bomb as being similar to a tactical weapon seems to indicate that the yield of these devices must be smaller than the smallest atomic bomb (namely, in the 10 kiloton range), and would depend upon the neutron radiation for its destructive properties. The biological effects of fast neutrons are generally known for they cause intense damage in the biological systems through the interactions with the hydrogen atoms of organic matter (high-energy proton recoil).

The yield of fast neutrons in such device could be in the range of 10^{22} m^{-2} sec^{-1} compared to laboratory neutron sources in the range of 10^{14} as described earlier. It is indeed unfortunate that technology has developed such an intense source of neutron radiation that can be projected through rockets and missiles. This gives a new dimension to the subject of nuclear proliferation for it may well mean that there is no need for uranium or plutonium for producing nuclear lethal weapons.

As far as pure science goes, the ability to produce fusion neutrons in such large quantities is an interesting development and could lead to several basic research applications such as production of new isotopes by multiple neutron capture processes and conversion of fertile material into fissile material, for example, ^{238}U into ^{239}U, or thorium into ^{233}U.

One special characteristic of a neutron bomb would be that it could avoid detection at long distances through the standard seismic methods for the radiation could not be detected at great distances, and since the blast energy is minimal, it will not produce characteristic seismic signals when exploded underground. It is possible that testing of such devices has gone on for several years even as the superpowers were negotiating test-ban treaties and it is only now that a formal announcement has been made. This shows that the realities in the development of more lethal weapons are far ahead of what is talked and negotiated in these meetings.

M. C. JOSHI

[Dr. Joshi is Professor and Head of the Department of Physics, University of Bombay.]

Round-up of Research *(Contd. from p. 31)*

In their experiments, reported in *Science* (**196,** 877, 20 May 1977), they identified in the fossil leaves, by the technique of paper chromatography, the flavonol kaemferol and dihydrokaempferol, the flavanonol form of kaempferol.

They state that their results suggest that the flavonoids from the fossil *Z. oregoniana* represent original unaltered flavonoids. According to them, the rapid burial of the leaves under volcanic ash and the apparent lack of elevated temperatures in their subsequent geological history explain the preservation of the organic compounds. The material from the Succor Creek flora, in fact, represents the first case of the preservation of flavonoid compounds in comparably aged rock strata.

K. A. NEELAKANTAN

TELL US WHY...

. . . peoples' voices sound different?

Basically, for the same reason that soldiers are ordered, while crossing a bridge, to break their marching rhythm.

Like a pendulum, a bridge has its own natural frequency of oscillation. This is just the frequency at which it oscillates when it swings freely. And since a pendulum can be made to swing wildly by "pushing and pulling" it in time with its natural frequency, so, legend has it, bridges are apt to collapse if the rhythm of the soldiers' marching matches that of the bridge. Putting it more generally, any oscillating system can be made to oscillate strongly by subjecting it to external forces which oscillate with the same period. Such "sympathetic vibrations", called resonances, are responsible for approximately half the interesting phenomena in physics, including those of radio, television, musical instruments, photosynthesis, sight and hearing, elementary particles, atomic spectra, and the human voice.

The most interesting and useful property of resonating systems is that they respond more or less selectively to external periodic forces. A system with a natural frequency of 200 cycles per second (cps) will respond strongly to an external force with the same, or nearly the same, frequency. But it would not respond sympathetically if the force frequency was, say, 250 cps.

Fig. 1

A system may have several natural frequencies. For instance a taut string has an infinite number of resonant frequencies with relative ratios 1 : 2 : 3 . . . . etc, so that if the lowest frequency at which it resonates is 200 cps, then it will also resonate at 400 cps, 600 cps, etc. Similarly, an air column in a tube which is closed at one end and open at the other, has many resonant frequencies, but these are in the ratio 1 : 3 : 5 : 7, etc (see Fig. 1). What does all this have to do with the human voice?

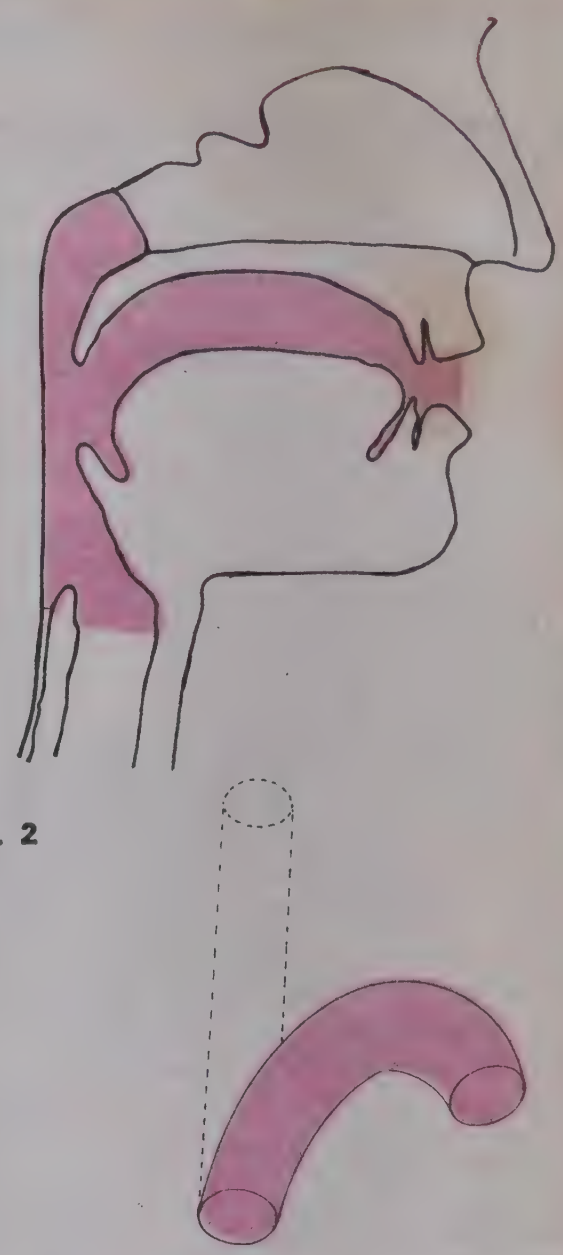


Fig. 2

After considerable mental simplification (see Fig. 2), the human vocal tract may be likened to a tube which is closed at one end (at the glottis) and open at the other (at the lips of the mouth). In an average man, this tube is around 17 cm long. A half-open tube of this length (actually the air column inside it) should have resonant frequencies of 500 cps, 1,500 cps, 2,500 cps and so on.

Now what happens when we speak? Air from the lungs is forced past the vocal chords (glottis) which vibrate like the reed of a clarinet sending into the vocal tract an output consisting of a jumble of frequencies. But here the *selective response* of the tract comes into play — only those frequencies near 500, 1,500 and 2,500 cps are 'picked up', so that the sound output near the mouth (that is, the "voice") consists primarily of just these frequencies, plus of course some residual frequencies.

What about the *shape* of the vocal tract? How does it affect the sound output? It turns out that this determines the loudness at which each individual natural frequency is excited. Thus, the natural frequencies themselves depend mainly (but not solely) on the *length* of the vocal tract, but the relative mix of these frequencies in the final output depends mainly on how the *shape* of the tract is varied.

Peoples' voices sound different because of the different 'resonant properties' of their voice tubes. Except for loudness, the lungs don't have much to do with the problem. What we hear depends on the length of speaker's voice tube, and how he uses his throat muscles.

VIVEK MONTEIRO

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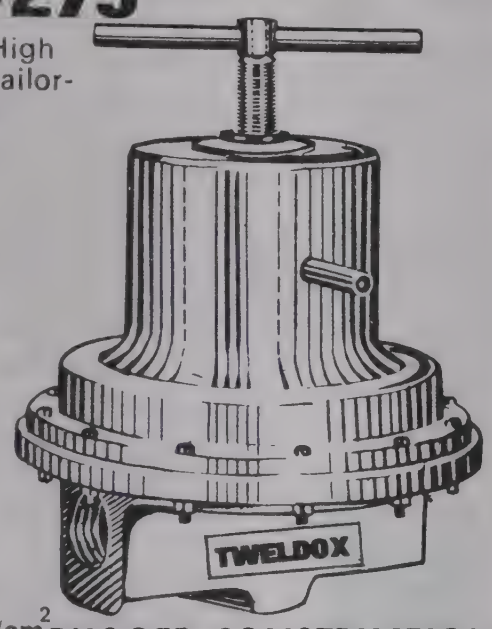

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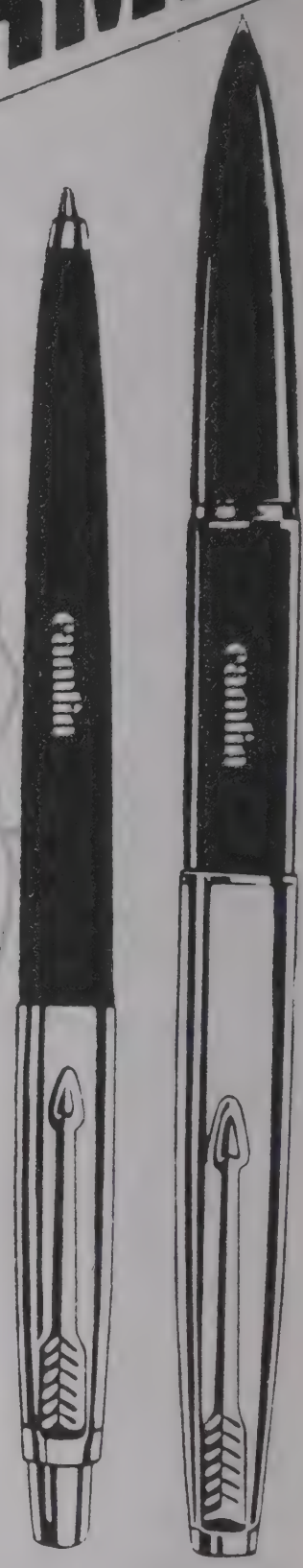

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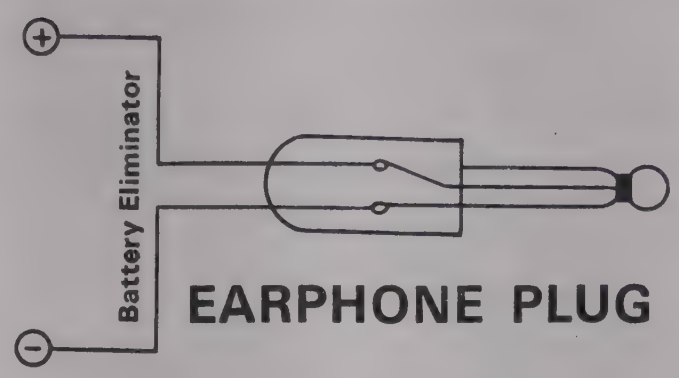
BATTERY ELIMINATOR

It is not economical to use transistor radios, transistorised cassette players, or any other electronic gadget with dry batteries where mains supply connections are easily available. You can build yourself a mains-operated battery eliminator which can supply the appropriate DC supply to operate the devices.

As you know, the mains supply available almost throughout the country is 230V AC, 50 Hertz. The transistorised devices, depending upon their type, work either on 3, 6, 9 or 12 V DC supply and their current requirement is normally within 250 mA. Transistor radios normally work on 3 or 6 V DC batteries and their current requirement is within 100 mA. The cassette recorder/players work on 6 or 9 V DC batteries and their current requirement is within 200 mA. With the circuit given below, you can select any voltage, 3, 6, 9 or 12 V DC with the selector switch and the maximum current the circuit can provide is 250 mA. However, if you require any other DC voltage source, up to 90 V DC and 250 mA, you can design your own battery eliminator unit, using the basic circuit and the data given below.

The battery eliminator, basically, consists of three parts: a step-down transformer, bridge rectifier and filter circuit. The step-down transformer provides across its secondary, the necessary low voltage AC supply to the bridge rectifier. The bridge rectifier converts the AC voltage to DC. Though this voltage provided by the rectifier is DC, that is, unidirectional, it has still a fluctuating nature. The capacitor across the output is called filter capacitor, which acts like a fly wheel and provides a steady DC output. The resistor across the capacitor is called bleeder resistor.



You might wonder why the DC output voltage available is slightly more than the AC voltage provided by the transformer secondary. This is because the AC voltages are always specified as the R.M.S. value of its sine wave behaviour, whereas the rectified output across the filter capacitor has the tendency to attain the peak value. The theoretical equation of the DC (V DC) voltage under no load condition, across the capacitor, is given below.

$$V\,DC = V\,AC \times \sqrt{2} - 1{\cdot}2\ V$$

where 1·2 V is the drop across the silicon bridge rectifier.

The value of V DC drops slightly, depending upon the current drawn from the battery eliminator.

For all practical applications, where V DC $\gg$ 1·2 V, under normal loading condition

$$V\,DC = 1{\cdot}2 \times V\,AC\ (approx.).$$

By fixing the earphone socket on the cabinet of the transistor radio and the plug to the output terminals of the battery eliminator, one can provide a very handy arrangement which disconnects the internal dry batteries of the transistor radio or cassette player when the plug is inserted inside the socket; the connections are brought into play when the plug is removed. With the battery eliminator, the transistor radio or cassette player can thus be used with dry batteries, and inside the house, by simply inserting the plug into the socket.

You will need:

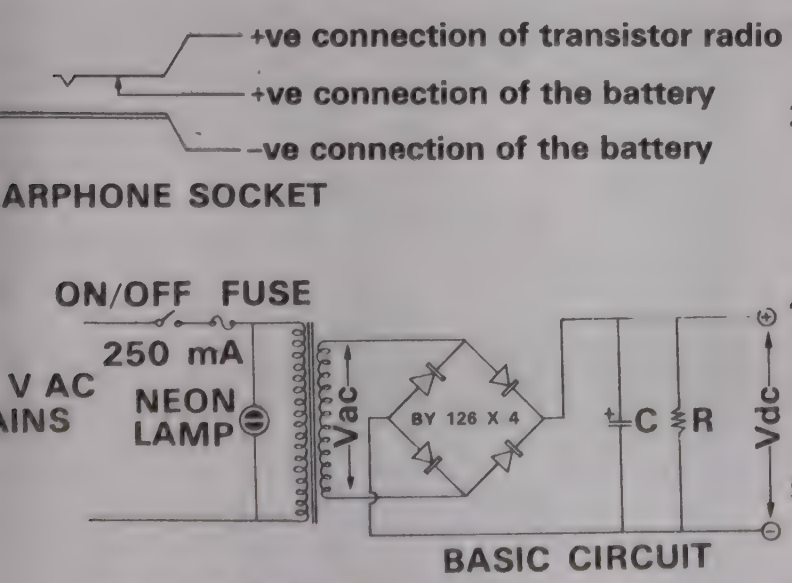
Semiconductors: silicon rectifiers, BY 126, 4 nos.

Transformer (made to order): Pri: 230 V A.C.; Sec: 0–3·5–6–8·5–11 V A.C. @ 250 mA, 1 no.

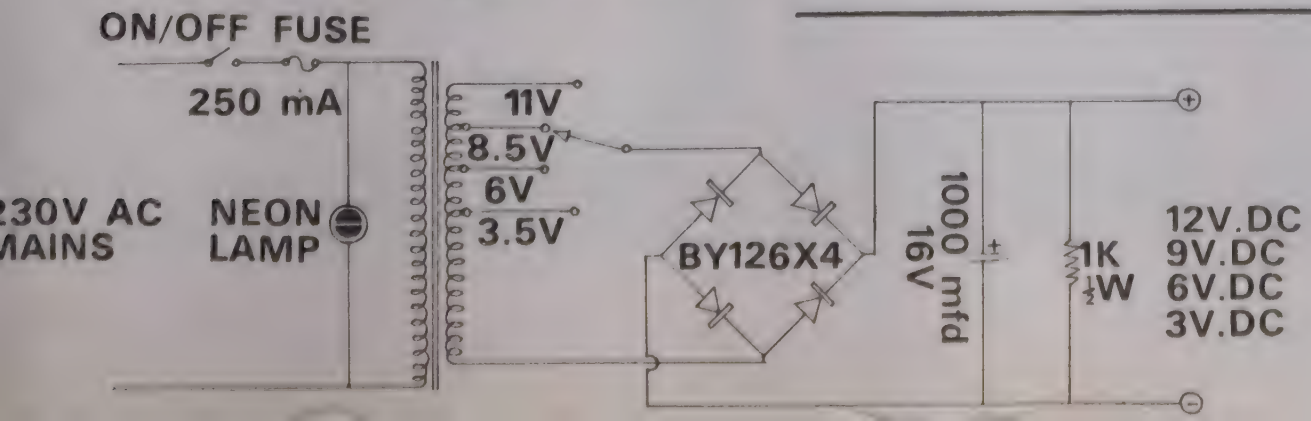
Capacitor (electrolytic): 1000 mfd 16 V, 1 no.

Resistor: 1K 1/2 watt, 1 no.

Switches: On/Off switch, 1 no.; 1 pole, 4 way, 1 no.



DC OUTPUT REQUIREMENT V DC VOLTS	mA (MAX.)	TRANSFORMER (Pri = 230 V AC) SECONDARY V AC	mA	CAPACITOR C	BLEEDER RESISTOR R
22·5 V	50 mA / 100 mA / 250 mA	18·75 V	50 mA / 100 mA / 250 mA	250 MFD / 500 MFD / 1000 MFD — 25 V DC	4·7 K ½ W
45 V	50 mA / 100 mA / 250 mA	37·5 V	50 mA / 100 mA / 250 mA	250 MFD / 500 MFD / 1000 MFD — 50 V DC	10 K ½ W
90 V	50 mA / 100 mA / 250 mA	75 V	50 mA / 100 mA / 250 mA	250 MFD / 500 MFD / 1000 MFD — 100 V DC	22 K 1 W



Fuse: 250 mA with fuse holder, 1 no.

Misc.: neon lamp (230 v type); earphone plug socket; suitable enclosure; terminals; lug strip or group board; wires, solder, screws, knob, mains plug, etc.

ANIL V. BORKAR

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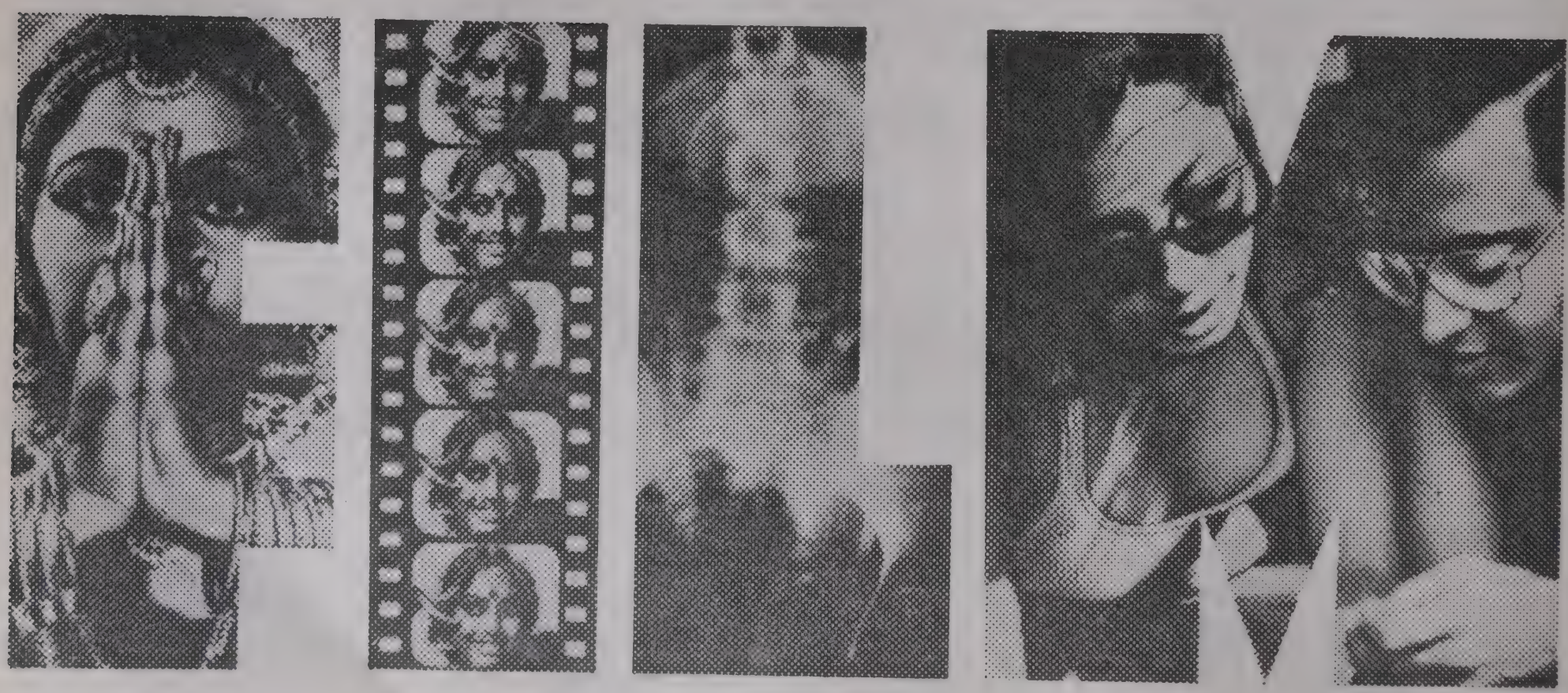

SAA/HPF/2214

BRAIN TEASERS

FOUR AILMENTS: If 70 per cent of the population of a certain town have stomach trouble, 75 per cent have cataract, 80 per cent have liver ailment, and 85 per cent have a touch of catarrh, what per cent, at the least, are plagued with all four ailments?

K. S. S. NARAYANAN

THREE FRIENDS: Each of three friends, Arun, Binod and Charan, practises a profession and a hobby. Among them, they have six professions and hobbies. The following facts are known about them:

The teacher lent a rare book to the banker.

One day Charan gave a lift to both Binod and the banker in his car.

Both the social worker and the philanthropist were entertained by Arun.

The grocer obliges the banker by depositing his savings in his bank.

Binod and the philanthropist are the office bearers of a cultural organisation.

The grocer praises the social worker for his selfless service.

One of them is a cricketer. Can you find out who is who?

V. A. SHENAI

(Solutions next month.)

Solutions to last month's Brain Teasers

Many-in-one

93

Family affair

This can be solved by marking X for 'no' and √ for 'yes' in the sequence 1 — 25 as shown in the table below. To start with, C and D are not principal (mark 1 and 2); neither are they vice-principal (mark 3 and 4), since the latter is a bachelor and the others are married. For a similar reason, mark 5. E is neither student counsellor (his brother-in-law) nor hostel warden (seen with him—mark 6 and 7). Similarly, mark 8. B is not principal (mark 9) since he was not present on the first day. E is not principal (mark 10) since he was seen with the principal. Hence, mark 11 and also 12, 13, 14 and 15. Then mark 16 — 25 to complete the table —

Post	A	B	C	D	E
Principal	11√	9X	1X	2X	10X
Vice-principal	12X	16√	3X	4X	5X
Student Counsellor	13X	17X	21X	23√	6X
Hostel Warden	14X	18X	20√	8X	7X
Nil	15X	19X	22X	24X	25√

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AWARDS & APPOINTMENTS

y Tata Memorial Awards

ive foreign scientists have been awarded the Lady Tata orial International awards for 1977-78 for studies in the ses of the blood, with special reference to leukaemias. The ds are made annually by the Lady Tata Memorial Trust.

he awardees are: Dr. R. Bastos, of Brazil, Rs. 56,000 00) for the study of molecular regulation of erythroid entiation in normal and leukaemic cells, at the Weizmann ute, Rehovot, Israel; Dr. P. Mignatti, of Italy, Rs. 24,000 00) for the study of transformation-enhancing factors ced by transformed and malignant cells, at Pavia, Italy; . Ravid, of Israel, Rs. 56,000 (£3,500) for an attempt to e and establish in culture the 'premalignant' and malignant of Mediterranean intestinal lymphoma, at Hebrew Univer- Hadassah Medical School, Jerusalem; Dr. H. T. Jacobs, itain, Rs. 24,000 (£1,500) for the study of controls on cription and RNA processing in normal and neoplastic cells, e Beatson Institute for Cancer Research, Glasgow; Dr. J. lerner, of France, Rs. 56,000 (£3,500) for the study of otype mixing of simian foamy virus and baboon (*Papio cephalus*) type C endogenous virus at the Imperial Cancer arch Laboratories, Lincoln's Inn Fields, London.

esides, the Trust has also given eight senior and eight scholarships for scientific studies in India, having a ring on the alleviation of human suffering from disease".

ERI Director

r. B. B. Sundaresan has taken over as Director of the nal Environmental Engineering Research Institute, Nagpur. undaresan has till now been Professor-in-charge of post- ate studies and research and also Dean of the College of eering, Guindy, Madras, in the Department of Technical ation, Tamil Nadu. Dr. Sundaresan had developed and ted a "dry process for control of nitrogen emissions from acid manufacture", while he was doing his post-doctoral rch in air pollution control systems at the University of la, USA.

OKS *(Contd. from p. 53)*

he book opens in the traditional fashion with a ussion on abstract group theory and then proceeds ne representation theory for both finite and conti- us groups. With the basic mathematical equipment eloped, it then proceeds to apply it to quantum hanics, incorporating various areas of atomic phy- crystallography and molecular symmetries, ending a chapter on the use of group theory in solid physics.

here can be little dispute about the basic material ered — it is by now standard. One would have liked ee a more detailed discussion of atomic, molecular nuclear physics — a simplified version of treatments ne standard books of Tinkham or Heine. The book ld then have been a great help in providing the ent community with an introduction to applications roup theory in the non-relativistic domain. Another c worth discussing would be the more elementary cts of the representation theory of symmetric groups useful in the discussion of representations of other ps.

A. A. RANGWALA

Rangwala is with the Physics Department, Bombay ersity.]

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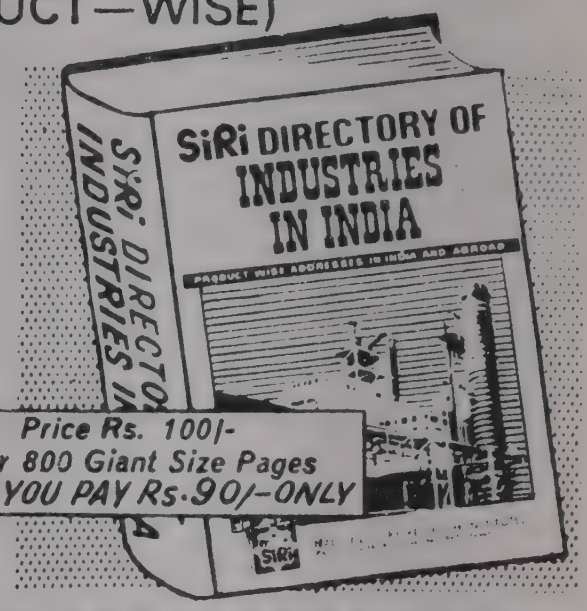

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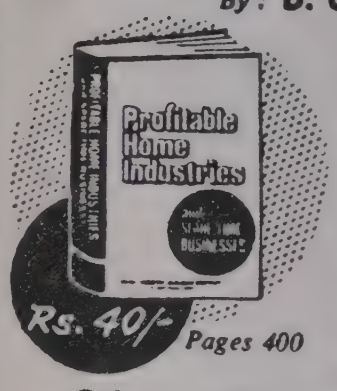

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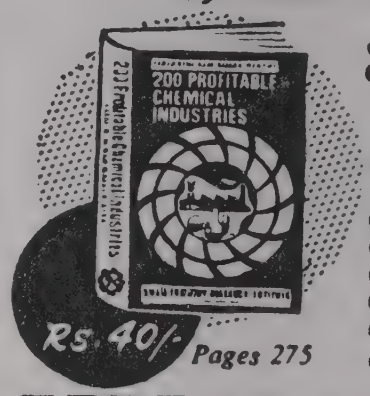

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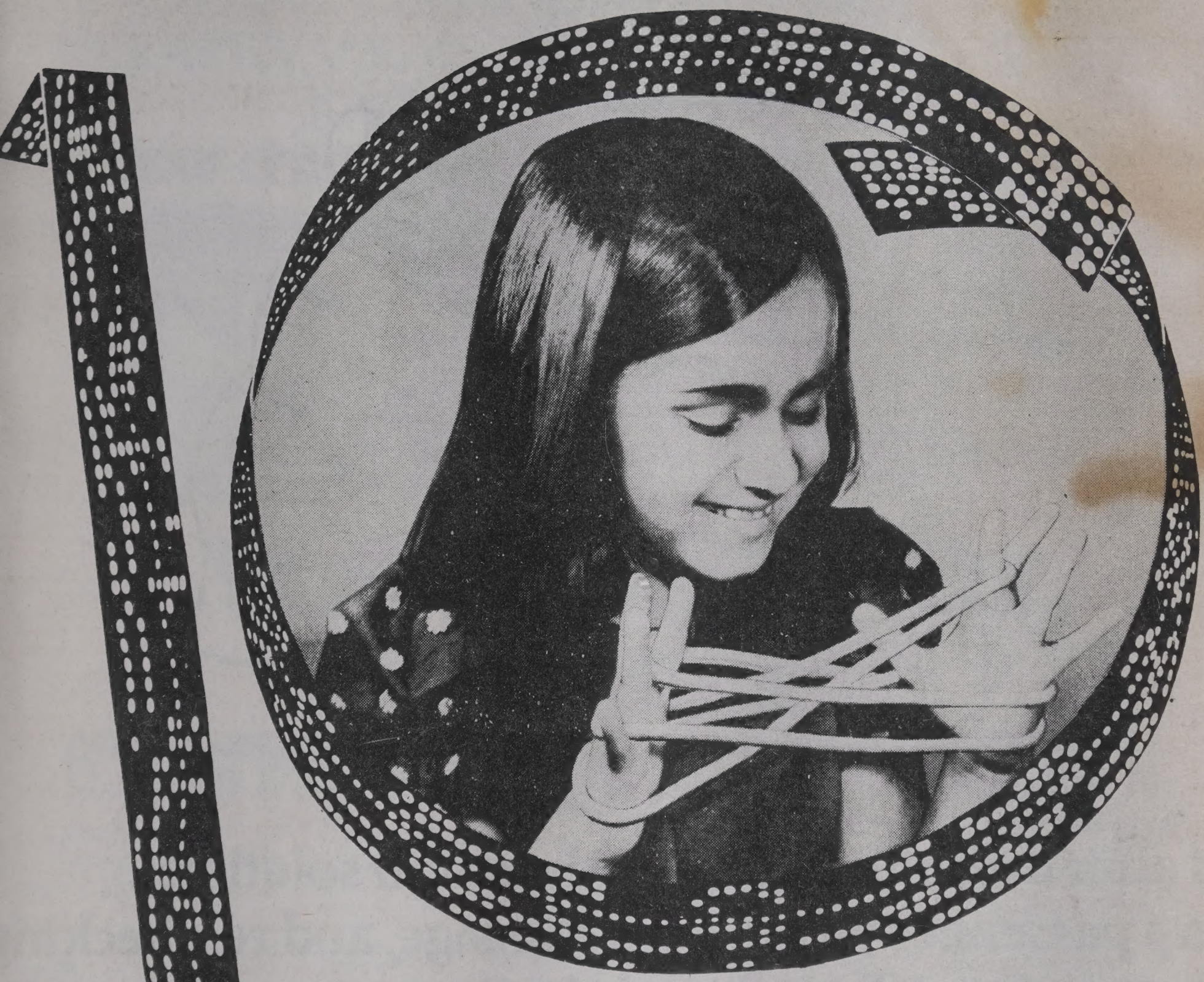

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He will juggle figures with the ease of a computer. The total weight of his 747 won't be a kilo over 351,000 kgs. And when a family of tourists comes off a flight, not speaking a word of English or Hindi, his sign language will guide them to a hotel of their choice.

He is only doing his job. Because he knows there is someone very special on board.

You, dear passenger.

AI.9352

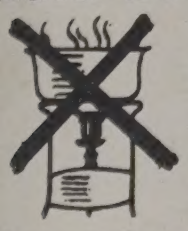
AIR-INDIA

If you have a child who falls ill with alarming regularity, you must read this advertisement. It tells you how to guard your child against water-borne diseases.

As a parent of a growing child, the first question that comes to mind is: 'How can it be humanly possible?'. How can a child be attacked by water-borne diseases, even after taking the trouble of boiling the drinking water. Yes, it does sound incredible. But sadly enough, it is true. Take for example, this extract from The Times of India dated May 4, 1977: **"Though no figures are available on infant deaths due to water-borne diseases, it is a well-known fact that children in the zero-to-five age-group form 17 per cent of the population, but they account for 40 per cent of the annual deaths."**

Your children are under constant attack!

t is scientifically established that boiling water is insufficient



It's now an established fact that boiling alone is no longer safe. Boiling only kills germs, **but not spores.** You need something that rids you of both. For, spores are the resting stage of bacteria present in water. And even a temperature of 100 degrees C (the boiling point of water) has no real effect on them. A few hours after boiling, they are back in action again, contaminating the freshly boiled water.

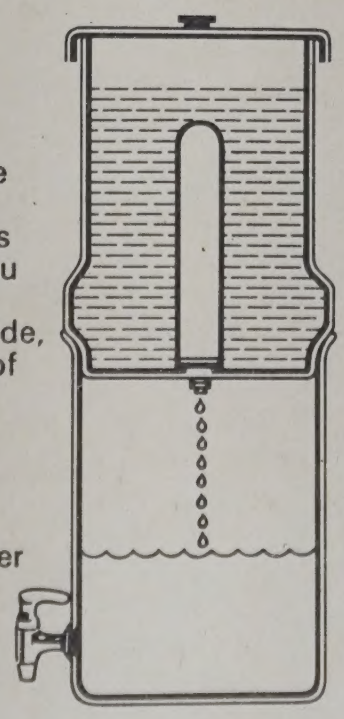
Beware of the Matka!

Ask any scientist friend. He'll tell you. Even boiled water stored in matkas is dangerous.

For matkas breed germs by the million, in their millions of earthenware pores. Why, even crystal clear water examined under the microscope shows bacteria which cause cholera, typhoid, dysentery, jaundice, gastroenteritis and other terrible diseases.

There must be a solution!

Don't worry! Serious as the problem is, the solution is really simple. Wise parents all over the country have adopted the Puritas Water Filter. As you can see in the illustration alongside, the filter consists of two chambers, candles and a tap. Water filled in the upper chamber, slowly and safely filters into the lower chamber through the candles.



The secret of the candles

The secret lies in the Puritas Candle, the first of its kind in India. All Puritas Candles are laboratory tested and certified by leading municipal authorities. These candles are made of a very special kind of earth called 'Kieselguhr' which is so precisely porous, it makes the ideal filtering material. In fact, **it filters out all germs and spores, providing you with 100% pure drinking water** in the lower chamber.

Where is the proof that Puritas gives 100% pure water?

We have proof. You are most welcome to come over to any of our offices in India and check photostat copies of actual laboratory test reports. You can also check the originals at our Head Office in Bombay—reports that prove without doubt that the Puritas Water Filter removes bacteria totally. Assuring you of water that is 100% free of germs and spores. 100% safe for your growing children and for you.

Caution

Buy only genuine Puritas Water Filters for your own safety. Check the Puritas label on the upper chamber. See that the Puritas name and Registration No. 196501 are on the metal base of the candle.

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